Regional Development of Russian Industry

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Thesis for the MSc degree in Environmental and Development Economics

UNIVERSITY OF OSLO

2008

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Preface

The author will like to thank her two supervisors, Karen Helene Ulltveit-Moe and Fredrik Wilhelmsson for their valuable comments and suggestions during this process. I also feel grateful for all the help and support I have received at the Norwegian Institute of Foreign Affairs (NUPI). In particular I want to highlight the outstanding assistance from the staff at the Department of International Economics and the Department for Russian and Eurasian Studies. They have been crucial for the result of my work.

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August 2008

Summary

In the early 1990s Russia embarked on the transition to a market economy, as an independent country but with institutions and other economic structures inherited from the Soviet Union. The combination of a regional differentiated industrial structure and lack of incentives for profitability has influenced Russia's regional development in productivity. How the sectors and firms have adjusted to the market system and their ability to restructure varies, and this has had implications for the regional distribution of industrial productivity levels.

In my thesis I have analyzed how relative productivity levels across the regions of Russia have developed during the period 1996–2004. As a measure on productivity level I have used labour productivity, defined as value added per worker employed in industry. I have focused on what has been traditionally regarded as the main Russian industries: oil and gas extraction, electricity production, mining and quarrying, together with manufacturing. The question I have tried to answer in my thesis is whether the regional productivity rates have converged or diverged during the period analyzed and how the observed pattern resonates with economic theory.

To answer my questions I have applied an empirical method using regional data from Goskomstat, which is the issuing body of official statistics in Russia. I have carried out convergence analysis to test for absolute and conditional convergence.

In my analysis I have found support for conditional convergence predicted by the Solow-model and the technology-gap model by Barro and Sala-i-Martin (1997), related to endogenous growth theory. Regional openness for trade and investment prove to be most important explaining the observed regional differences in growth rates.

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1. Introduction

Industrial production in Russia has undergone major structural changes. The break-up of the Soviet Union led to a change in the economic environment. The economy went from being based on a command system to moving towards a market-based system. The communistic command system had involved central planning of industrial location and production plans. It is reasonable to expect that the dismantling of the lines of command and the introduction of market incentives have affected the industrial composition, the geographical structure and the distribution of industrial productivity. I will look at how the process of adjusting to market forces has led to convergence or divergence in labour productivity among the regions of Russia.

The industrial structure in Russia by the end of the Soviet era was different from what normally occur in marked economies. Through central planning, industry was geographically decentralized, with mono-industrial towns scattered around the country (Maurseth 2006). Industrial development had high priority in the Soviet Union and many businesses were heavily subsidized. Low transport costs were an important tool to keep industry running in the periphery. As a result, at the start of the transition, Russia found itself with a higher share of employment in such industries relative to other countries at similar income levels (World Bank 2004), many of them located far away from the large markets. Since the communist system had encouraged production, not productivity, productivity differences at the end of the Soviet era were large.

The main purpose of this study is to analyse how the regional distribution of productivity in Russia has developed under the conditions of a market economy. As a measure of productivity I will use labour productivity, defined as value added per worker employed in industry. The focus will be on what has been traditionally regarded as the main Russian industries: oil and gas extraction, electricity production, mining and quarrying, together with manufacturing. I will later refer to this sector simply as the ‘industry sector’. According to economic theory, when opening up for market forces, investments will flow into the regions with the largest growth potential, and firms will adopt those technologies that maximize profit. Whether this will lead to convergence or divergence depends on the economic forces in action, as well as the regional specific characteristics. In economic theory there are two primary reasons for expecting convergence. First, there is the neoclassical argument, which holds that declining marginal productivity in capital tends to make the rate of return on investments higher in less productive regions. Second, according to the technology-gap argument, technologically less advanced regions are expected to have larger potential for technological improvements. Only equal regions are expected to converge to the same steady-state productivity level. If the regions differ with respect to business and investment climate, market access or resource endowments, then convergence is expected only when such differences are controlled for. In the presence of geographical local economic externalities or economies of scale, such differences could prove to be a source of divergence, however. New growth theory emphasizes the role of history for regional growth potential and economic agglomeration. Decisions regarding industrial location taken under central planning can determine which regions are likely to become the productive leaders in a market economy.

The combination of Russia's enormous geographical area, large resource endowments and a highly regional diversified industrial structure inherited from the Soviet past, makes analysing regional convergence in productivity in Russia particularly interesting. Barro and Sala-i-Martin (Ch. 11, 2004) argue that we are more likely to find convergence across regions than across countries, because, although differences in technology, preferences and institutions exist across regions, these differences are likely to be smaller than across countries. Russian regions share a set of legal, economic and political institutions; the population speak the same language and have a common socialist past. On the other hand, Russia's regions are largely heterogeneous with respect to some economic factors, such as resource endowments, geographical location and market access and industrial structure, providing a unique opportunity to analyse them in light of the hypothesis of convergence.

There exist few analyses of convergence within the industrial sector in Russia, but the general the empirical evidence from analyses of GRP (gross regional output) tends to support the convergence hypothesis (Merkina 2004, Maurseth 2006, Nielsen 2005). However, the results are not unequivocal (see for example Maurseth 2003). The industrial sector diverges from the other sectors in the Russian economy, because of its central role in the Soviet economy. While the market services have to a greater degree developed during the transition, the industrial sector carries a significant inheritance from the Soviet past, one that cannot change over night. In this context it is interesting to see whether focusing solely on the industrial sector will matter for the results of convergence.

Analysis of convergence in productivity has stressed the importance of industrial structure. Heterogeneous industrial structures across regions or countries could explain weak evidence of convergence. When differences in sectors are controlled for, a general finding is convergence. This could be relevant for Russia regarding the highly differentiated industrial structure and the strong position of resource intensive industry in some regions. Industries based on extraction and processing of natural recourse have attracted special attention in economic literature, because of the existence of large resource rents. Especially oil and gas production gives high value added per worker, but the high rents could also act to suppress incentives to invest in increased productivity in the long run. Possessing large resource endowments could be a blessing or a curse, depending on how they are utilized.

To analyse the development of productivity in Russian industry I will do an empirical analysis based regional data from Goskomstat for the period 1996 to 2004. I will test whether the regions have converged with respect to labour productivity over that period. Since only conditional convergence is expected I will control for regionally specific variables, such as investment in human and physical capital, population growth, migration, openness for foreign and initial industrial structure, with special emphasis on the natural resource sector. In addition I include an indicator reflecting regional market access, to see if there are any tendencies to economic agglomeration in the economy. In Chapter 1 I describe the political and economic climate in Russia in general, together with the Russian industry. In chapter 2 I explain the theory framework that underlies the empirical analysis. Chapter 3 presents a description of the Russian regions with respect to the core economic variables in the analysis, whereas Chapter 4 offers the empirical analysis and regression results.

2. Political and economic background

In the early 1990s Russia embarked on the transition to a market economy, as an independent country but with institutions and other economic structures inherited from the Soviet Union. The combination of a diversified industrial structure and lack of incentives for profitability has influenced Russia's regional development in productivity. How the sectors and firms have adjusted to the market system and their ability to restructure varies, and this has had implications for the regional distribution of industrial productivity levels.

2.1 The inheritance from the Soviet Union

By the end of 1991 the dissolution of the USSR was a fact. The underlying causes include an impaired state, a worn-out economy and increasing demands for independence among the Union's republics. A bankrupt and discord state could not prevent the movement of breakaway states. Effort to save the Union only accelerated the process.

Even though it is difficult to get an accurate measure of economic performance in the Soviet era, statistics indicate that the Soviet Union initially managed to maintain an impressive growth through capital accumulation, but during the 1970s and 80s the growth rate began slowing down and the development in productivity was actually negative. Even the industries of priority interest, such as steel, coal and petroleum production, experienced negative growth rates in factor productivity from the mid-70s (Gregory and Stuart 1986). The main reasons were lack of incentives to improve efficiency, a system incapable of restructuring, unbalanced priority to certain industries (like those connected to the military) and deteriorating terms of trade.

Much of the growth potential through increased use of inputs was exhausted by the end of Stalin's time. Large investments in capital were no longer as profitable. It became increasingly more difficult to substitute capital for labour. Major decisions regarding investments, production targets and price setting were taken in Moscow, which created massive problems of asymmetric information and monitoring. Attempts to reform the system toward higher productivity failed (Sutela 2003). Managers had no incentives for considering cost efficiency or investing in innovative activity: they were rewarded primarily for achieving pre-determined output targets (Gregory and Stuart 1986). The uniform production policy, focusing on production quantity, led to diversified productivity rates, large waste of resources and environmental stress.

Much Soviet investment, including R&D investment, went to the military sector or related activities. To achieve parity with US military forces, the production focus was increasingly directed towards heavy industry and the military industry. As a result, other goods, such as consumer goods, had relatively low quality and were not competitive. Soviets exports were heavily oil-dependent, so when oil production fell in the enormous oilfields in west Siberia, the Soviet Union had to take up loans from the West to finance necessary imports of consumer goods and new technology. By the time Gorbachev took over, the economy was in bad shape.

2.2 Russia towards the market

The transformation started under Gorbachev as an attempt to revitalize the Soviet economy, through the reforms collectively known as *perestroika,* which began in 1985. They included cautious attempts at privatization and marketization of the economy. However, with lack of real incentives and soft budget constraints, combined with increasing political support for the disintegration of the USSR, the attempts failed. Before the planned reforms could be fulfilled, the Soviet Union collapsed, and with support from Western economists a more extensive reform programme was developed. This reform was intended to ensure that there would be no return to a planned economy, by creating a new generation of capitalists. The basic elements were price and trade liberalization, privatization and fiscal stabilization.

Shock therapy

Implementation of the reform was meant to be quick – to utilize the 'window of opportunity'. The argument was that with time the old machinery of power could gain enough strength to hamper the reforms. A further argument was that rapid implementation would reduce the opportunities for insiders to exploit the reform for their own gains. On January 1992 the implementation of transition policies started, with abolishing the system of fixed prices. Approximately 90% of retail and 80% of producer prices were freed (Ahrend and Tompson 2005). Over the following years, state enterprises became privatized. Most enterprises were privatized during the first great privatization wave in 1993/94, except for some highly valuable and key sectors like the extraction industries. These were to a large extent taken over by private owners, often referred to as 'oligarchs', during 'the loan for share' process prior to the presidential election in 1996. On the whole, by the beginning of 1997 much of the privatization process had been accomplished and private enterprises now accounted for a large part of industrial output.

Crisis and criminals

The transition was marred by great problems. Falling demand and loss of old markets put great challenges on an inexperienced industrial management. The power vacuum following the collapse of the old system created room for rent seeking and fraudulent economic behaviour. With weak financial policy performance, the consequences were rapid inflation, falling production and investments, together with a criminalization of the economy.

Growth rates had already been diminishing, but with the collapse of the Union they turned negative. GDP fell by no less than 40 percentage points during the transition until the financial crisis of 1998. In comparison, the US economy had shrunk by 30% under the Great Depression of the 1930s (ECE 2004). Russia's transformation cost far more than expected – the ability of the economy to adjust and the government to create a stable political development had been overestimated. When the old commando and supply lines were dissolved, trust and experience had to be established with the new market-based system. It was believed that the reform would create a new class of capitalists, which would develop and make Russian industry profitable.

In reality, firms ended up in the hands of a few insiders, who used their newly acquired assets for private short-term gain. Abuse of position and fraudulent behaviour had existed during the Soviet period, but went out of control under the power vacuum that ensued with the demise of the old system. The uncertain political and economic climate gave few incentives for long-term investments. At least a fourth of all businessmen were linked to the criminal underworld, according to Moscow region policy chief Alexander Kulikov (Sakwa 2002). Lacking resources, the government was simply not able to protect the newly-established property rights. Security companies emerged as big business for businessmen who needed protection against other criminals.

Price liberalization led to massive inflation, when firms lacked incentives to respond by increased supply. The industrial structure inherited from the Soviet era was a largely monopolistic one. Up to one third of all industrial enterprises were monopolies, producing goods that no one else in the USSR did (Sakwa 2002). In the absence of competition, and with an uncertain investment climate, it was more profitable to meet excess demand with increased prices rather than investing in production. Indeed, inflation did fall after the first shock, but loose monetary policy intended to finance the government's massive budget deficits made it surge again (Ahrend and Tompson 2005). Inflation started to decline only after the government and the Central Bank of Russia (CBR) introduced a more stringent monetary policy in 1993. By 1996 it was basically under control.

Lack of security for property rights and an inadequate banking system contributed to the plummeting investment rate during the 1990s. The absolute level of investments fell by around 75% for 1990–2000 (Sakwa 2002). Since the banking system mostly financed inside businesses, investment credits had to come from the firms themselves.

Indicators Russian economy % of previous year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Growth in real GDP	–5	–14.5	–8.7	–12.7	–4.1	–4.9
Growth in real industrial production	–8	–18	–14	–21	–3	–4
Growth in real capital investments	–15	–40	–12	–24	–10	–18
Consumer price index	260	2609	940	315	231	122
Industrial price index	340	3380	1000	330	270	125.6

Table 2.1: *Indicators of the Russian economy. Source: Goskomstat*

After some years of more stringent monetary policy and with the re-election of Yeltsin, the economy seem to start stabilize. Before the collapse in 1998, economic prospects looked brighter for a while. But then, on 13 August 1998, the Russian stock, bond, and currency markets collapsed as a result of investor fears that the government would devaluate the rouble and default on domestic debt. It had now become clear that the Russian government no longer could finance its deficit through further loans.

Post-crisis Russia and the Putin era

The financial crisis proved short-lived and had a relatively modest impact on GDP. The sharp devaluation of the rouble served to boost competitiveness in Russian industry. The Russian economy had reached its bottom line. When the new millennium began there was some evidence that production was becoming more profitable than asset-stripping, and by 2001 the World Bank could take Russia off the ‘crisis list’ (Sakwa 2002).

The crisis had reduced political resistance to the necessary economic reforms. In the wake of the 1998 crisis, steps were taken to bring the governmental budget under control. Massive cuts in public spending were carried out, including reduced industrial subsidises and social transfers. In 2000 Vladimir Putin took over at the helm, and with him came increasing economic and political stability that continued throughout his presidency. The explanation for this success can be found in the combination of the ‘Putin effect’ and the political and economic reforms carried out under him, as well as a range of favourable external factors.

Putin came to power at a time when the Russian economy had just started its recovery after the financial crisis: the crude oil price was increasing and the sharp rouble devaluation had boosted industrial competitiveness. The rouble was devaluated in the mid-90s as well without the same effect on competitiveness, but by 1998 the reformation of the Russian economy had been accomplished sufficiently for the economy to react to market signals. Better terms of trade were met with increased production.

With increasing oil prices, Russia has experienced a large trade surplus, a factor vital for relief of its foreign debt. The election of president Putin gave further confirmation against a reversal of property rights. Under him the work of combating economic crime and improving the investment climate started. One of the steps is the de-bureaucratization reform aimed at simplifying and streamlining the procedures for registering new businesses. Initially the effect was positive and the administrative burden on firms was reduced, but this progress seemed to stagnate towards 2003 (CEFIR 2003). A reform widely considered as the most important one is the tax reform. Simplifying the tax system, broadening the taxation base and reducing marginal tax rates served to boost incentives for investment as well as federal tax revenues. The reforms have lessened regional legislative differences and the possibilities for local interpretations of the rules, although tax rates and regional investment climates still differ.

2.3 Regional politics

Soviet-era regional policies –'the conquest of the North'

The Soviet government had a clear strategy for spreading the production to new regions and small towns. Specific regions and towns were singled out as industrial locations. Many urban areas, especially in the North, arose as a result of central planning. Soviet mythology presented the North as the land of the future, an area which was to be 'conquered' (Blakkisrud 2006). The North,[1] including Siberia and the Far East, was endowed with many of the natural resources vital to industry.

The rapid industrialization that commenced with the first Soviet Five-Year Plan, in the late 1920s, brought with it the need for natural resources like coal, oil and heavy metals (ibid.). This meant the start of the industrial policies for the North and Far-Eastern regions, so richly endowed with natural resources. The eastward orientation was reinforced by the wartime evacuation of hundreds of factories were evacuated, to protect them from the Nazis.

To exploit the natural resources in the North labour, which was initially scarce in these areas, was needed. Under Stalin came the forced reallocation of labour. Through the Gulag system millions of people were moved to work in the North. After the death of Stalin, this system was gradually closed down and replaced by a set of social and economic incentive schemes, known as 'Northern benefits'. To sustain this scattered industrial structure, transport costs were kept artificially low. These policies promoted a relatively higher production and population density in higher latitudes than would probably be the case under a market system.

[1] For a definition the Russian North see Blakkisrud and Hønneland (2006), pp. 8–9. For which regions are regarded as included in the Russian North or partly included see appendix chapter 3: Regions.

Fragmentation and integration

Under the planned economy, the regional economy was basically a constituent part of the national economy. Production, consumption and investments were determined not by regional demand, but by state plan and the policies of federal departments. The centre exercised strict control over regional income flows (Granberg 2000). Even though the Soviet constitution granted to the republics certain rights of sovereignty, in practice these were highly circumscribed (Ross 2002).

Legal and economic fragmentation of the Russian Federation arose after the collapse of the Soviet Union. Dispersion of the systems for economic interaction together with a weak centre led to regional separatism. Many regions took advantage of the weakness of the federal centre under Yeltsin to size powers and control over regional resources. Tragically, many of the new regional institutions were forged by local authoritarian leaders who emerged out of the old Soviet nomenklatura (ibid.). The struggle for power has also led to an inward focus, and building up new trade lines has not enjoyed high priority. Inter-regional trade as a part of GNP fell from 22% to approximately 12–13% in the period 1990 to 2000 (Granberg 2000).

In the 1993 Constitution the rights of the federal units are equalized and made subject to the law and decisions of the federal authorities (Sakwa 2002). All the same, many regions have continued to pass and enforce regional laws, many of them inconsistent with federal legislation. This has had consequences for regional practice regarding the liberalization and privatization reform. Some regions have refrained from privatizing their industries and have refused to implement legislation concerning privatization of land. In conflict with the centre, withholding taxes was used as a tool for blackmailing the federal authorities. By the end of Yeltsin's period, the regional executive heads were running their federal subjects as personal fiefdoms (Sakwa 2000).

Putin's primary object has been to tighten federal control of the regions and create a unified economic and legal space. To achieve this and monitor the process, his first move was to divide the country into seven super-districts, to supervise that regional legislation is in accordance with federal law. Putin’s efforts to bring regional legislation in line with the 1993 Constitution and federal statues have showed results. The work of simplifying the bureaucracy and the tax system has also helped to strengthen the centre/ periphery relationship. Today’s Russia has, to greater extent, become a unified legal space and an integrated national market.

2.4 Industry under transition

By the end of the Soviet era, Russia was highly industrialized and served the other FSC-countries (Former Soviet Countries) with manufacturing and engineering products, together with petroleum products. Mechanical engineering, food and light industry were the three largest industries (Granberg 2000). Petroleums products were the most important export article, and were crcucial for the trade with countries outside the Soviet Union. The transition led to major structural changes in the composition of industry, on national and regional levels. The economy moved towards being more based on resource industries, especially oil and gas production. Especially hard hit was the manufacturing industry, together with mechanical engineering, chemical and forest industries. Important factors here were falling national demand, loss of international competitive ability and cutbacks in state subsidies. Faced with increased competition, industry had problems undertaking the necessary adjustments. With the dismantling of the rouble zone, old supply lines ceased to exists. Russian products faced competition problems when the CIS countries opened towards the West. According to OECD (1995) calculations, the disruption of the trade with CIS countries contributed to 10% of Russia’s economic decline in the early 1990s.

Since 1998 the pace of structural change has slowed down, and part of the manufacturing industry has begun to catch up again. Intra-sectoral change has become an increasingly important source of productivity growth. With the devaluation of the rouble, Russian industry became more competitive on the international market. Although many firms increased production by utilizing existing input, those firms that managed to actively restructure also increased their employment. Especially after 2002, the easy gains from the devaluation became exhausted and the firms that had increased productivity managed to do so through active restructuring (Ahrend 2004).

2.5 Regional differences

With respect to the mono-industrial pattern across regions, the introduction of the market mechanism had varying regional consequences. Those regions that inherited the 'wrong' industries experienced huge losses. Granberg (2000) has identified three especially vulnerable types of regions: those with high concentration of manufacturing industry, peripheral regions, and those dependent on federal transfers. Among the latter, regions or centres based on military industry found themselves in a particularly difficult situation during the transition. Northern peripheral regions without large reserves of natural resources were hit especially hard. The industrialization of this area had been to some extent policy-dictated and did not reflect real economic costs. Transportation costs rose during the transition, and many Northern enterprises started running at huge losses. The winners were the regions endowed with oil, gas, non-ferrous metals and diamonds, and nodal centres. (See Blakkisrud 2006.)

3. Theories of regional development

How will the distribution of productivity rates develop when the economy is transformed into a market economy? According to economic theory, with the opening up for market forces, investments will flow into regions with the largest growth potential, and firms will adopt technologies that serve to maximize profit. These mechanisms are expected to lead to convergence, for two reasons: decreasing marginal factor productivity, and the transfer of technology from regions at the productivity (technology) frontier to relatively less productive regions, which have greater potential to improve their productivity through investing in technology. In the absence of one or both of these assumptions, economic agglomeration and divergence may emerge. In the case of Russia, geography and initial industrial structure, including the country's large resource industry, may obstruct the results of convergence.

The hypothesis of convergence originates from neoclassical growth models in the tradition of Solow (1956), Cass (1965) and Koopmans (1965). The models aim to explain growth dynamics in a period of transition, while long-term growth rates are taken as given. The central mechanism is decreasing return to capital, which leads regions to converge towards a common long-term growth rate of labour productivity. More recently, inspired by endogenous growth theory, convergence has been applied to the hypothesis of technological catch-up. Through transfer of technology from the most productive and innovative regions, regions lagging behind are expected to catch up. In the tradition of New Growht Theory (NGT) Barro and Sala-i-Martin (1997) have derived a formal model describing these mechanisms.

If the technological spillovers are geographically restricted or tied to certain sectors, the result could be economic agglomeration instead. Geographical distance may act as a barrier – if, for example, transport costs are significantly high. Even though transport costs in Russia have been held artificially low, they have been rising during the transition. Krugman (1991) presents a model describing a source of agglomeration working through the size of the market.

Regional differences in industrial structure could act as a barrier to technological spillovers across regions. If some sectors have greater growth potential than others, this could lead to different steady-states or even disrupt the result of convergence. The dependence on resource-related industries in Russian economy makes it relevant to consider this sector in particular. The above discussion forms my theory basis. In the following, I present the central theories in more detail in light of the hypothesis of convergence.

3.1 Neoclassical growth theory

In the original Solow model there are two factors in production, capital (K) and labour (L). Increased output per capita (y) comes through an increase in the capital/labour ratio ($k = \frac{K}{L}$) and technological progress (x). Since the Solow model assumes full employment, output per capita is equivalent to production per employed labour and is proportional to labour productivity as I measure it. Because the model assumes decreasing marginal productivity of the factors in production, increases in per capita output through investment in capital are only transitory, and diminish as the economy approaches its steady-state capital/labour ratio. In steady-state, investments in increased capital/labour ratio do not increase productivity, and the only source of growth is the exogenous rate of technological progress. Assuming that technology is a public good, all regions will have access to the same type of technology, and thereby grow at the same long-term growth rate. Diverging growth rates are explained by differences in the regional possibilities to grow through investing in increased k, which depends on how far the regions are from the steady-state level of productivity. From the two central equations in the model, we can derive the growth dynamics in production per capita. Equation 3.1) is the production function measured in output per effective amount of labour ($\hat{y}_t = \frac{Y_t}{(AL)_t}$), while equation 3.2) depicts the growth in the ratio of capital per effective amount of labour ($\hat{k} = \frac{K}{AL}$) over time.

3.1) $$\hat{y} = \frac{Y}{AL} = \frac{1}{AL} F(K, AL) = f(\hat{k}) \qquad F_i^{`} \geq 0 \ , \ F_i^{``} \leq 0 \ \ i = K, L$$

3.2) $$\frac{\dot{\hat{k}}}{\hat{k}} = s \frac{f(\hat{k})}{\hat{k}} - (x + n + \delta)$$

The model is dynamic, so all the variables are a function of time. The production function has the properties of positive but decreasing marginal productivity in inputs and exhibit constant return to scale. n stands for the growth in the workforce, s the saving rate and δ the rate of capital depreciation. A(t) is defined as labour-augmenting technology, growing at a constant rate x. Barro and Sala-i-Martin (2004, Ch.1) have shown that only labour-augmenting technological progress (A), defined to hold the effective relative input shares constant, is consistent with the existence of a steady-state in general. The steady-state is then defined by a fixed ratio of capital and output per effective unit of labour ($\hat{k}^*, \hat{y}^*$). In steady-state growth, $\hat{k}$ is zero ($\dot{\hat{k}}^* = 0$) and since $\hat{y}$ only is growing in $\hat{k}$, growth in output per effective amount of labour $\dot{\hat{y}}^* = 0$. Assuming constant elasticity of production in the inputs, the production function can be expressed in a Cobb-Douglas functional form[2]. For this functional form the character of the technological progress is unimportant for the result and labour-augmenting technological progress could also be intepreted as growth in total factor productivity (TFP). The steady-state level of $\hat{k}$ and $\hat{y}$ is then characterized by equation 3.3) and 3.4) respectively, where α is the elasticity of production in capital.

3.3) $$\hat{k}^* = \left(\frac{s}{(x + n + \delta)} \right)^{\frac{1}{1-\alpha}} \qquad 0 \prec \alpha \prec 1$$

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[2]Cobb-Douglas production function with constant return to scale retains the characteristics of the Solow model.

3.4) $$\hat{y}^* = \left(\frac{s}{(x+n+\delta)}\right)^{\frac{\alpha}{1-\alpha}}$$

Using equation 3.3) to substitute for s in equation 3.2) we get an expression for $\frac{\dot{\hat{k}}}{k}$ as a function of $\hat{k}^*$, given by equation 3.5).

3.5) $$\frac{\dot{\hat{k}}}{\hat{k}} = (x+n+\delta)\left[\left(\frac{\hat{k}}{\hat{k}^*}\right)^{\alpha-1} - 1\right]$$

We see that the growth in the rate of capital depends on the ratio $\frac{\hat{k}}{\hat{k}^*}$. The rate of growth in output ($\frac{\dot{\hat{y}}}{\hat{y}}$) is in a α-proportion to the growth in $\frac{\dot{\hat{k}}}{k}$. Therefore we can use equation 3.5) and substitute $\hat{y}$ for $\hat{k}$ from the production function to find an expression for $\frac{\dot{\hat{y}}}{\hat{y}}$ as a function of $\hat{y}$ and $\hat{y}^*$. The expression is depicted in as in equation 3.6).

3.6) $$\frac{\dot{\hat{y}}}{\hat{y}} = (x+n+\delta)\alpha\left[\left(\frac{\hat{y}}{\hat{y}^*}\right)\frac{\alpha-1}{\alpha} - 1\right]$$

Since α is defined as less than 1, from equations 3.5) and 3.6), we see that the growth rates decrease as $\hat{k}$ and $\hat{y}$ increase and approach their steady-state levels. An approximate for the rate of convergence in the neighbourhood of steady-state can be found from a log linearization of equation 3.5) or 3.6). Using equation 3.6) gives us equation 3.7), where β is an approximate of the convergence coefficient, measuring how much the growth rate declines with a proportional increase in output.

3.7) $$\frac{\dot{\hat{y}}}{\hat{y}} = -\beta\left[\ln \hat{y} - \ln \hat{y}^*\right] \quad \beta = (x+n+\delta)(1-\alpha)$$

β approximately measures the speed of convergence in the nearby steady-state. Equation 3.7) is used as a starting point when testing for convergence. When $\hat{y}$ equal $\hat{y}^*$ then $\frac{\dot{\hat{y}}}{\hat{y}} = 0$ and the capital/labour ratio (k) and output per capita (y) will grow at a rate equal to the rate of technological progress (x).

The Solow-model assumes a perfectly competitive world, where the marginal returns to the factors of production are equalized across states. In the Cobb-Douglas example this implies that all sectors have the same technology parameter α. Any differences in steady-states in the original Solow model are due to differences in the consumers' time preferences, growth in the workforce or the rate of depreciation[3].

The Solow model has since been augmented to provide a better fit with observed patterns. Mankiw, Romer and Weil (1992) show that when human capital is included, the explanatory power of the model increases significantly. The implication for the result just derived is that steady-states also are characterized by the rate of investment in human capital and that the expression of β now also depends on the elasticity of human capital in production.

[3] The saving rate is exogenous in the Solow model. Cass (1965) and Koopman (1965) have endogenized the saving behaviour, but the main results remain.

3.2 Catching up in technology and the role of spillovers

Endogenous growth theory has been developed to describe observed differences in long-term growth rates. The theory tries to explain factors underlying different long-run growth paths, or the absence of such. The literature provides a range of new explanations for various steady-states and opens for differences in the long-term growth paths. In a tradition initiated by Romer (1987, 1990), and extended by Aghion and Howitt (1992) among others, long-run growth is explained by technological progress through innovation of new intermediate products. Productivity in the final goods sector is assumed to grow in input variety. Differences in steady-states are explained by differences in regional policies encouraging own research and development (R&D), but also openness to other markets. The latter is important, since trade gives access to new products, innovated in other regions and countries. Through giving increased access to variety of inputs trade has a positive impact on the productivity of a region.

Technological diffusion plays a key role in whether laggard regions tend to catch up or not. The 'catch-up' argument, developed by Gerschenkron (1962), Abramovitz (1986) and others, emphasizes the distance to the technology frontier for the scope of imitation. Countries behind the innovation frontier, it is argued, can grow faster by coping technologies already developed in technologically more advanced countries (Fagerberg 1995). In his famous paper from 1962, 'Economic Backwardness in Historical Perspective', Gerschenkron argued that relatively backward economies such as Germany, France and Russia would manage to catch up by adopting frontier technology during the 19^{th} century.

Barro and Sala-i-Martin (1997) formalize this argument in a model where the relative cost advantage to be gained from imitating desirable technology serves as a mechanism for convergence. Based on the framework for technological progress of Romer (1990), they describe the transitory dynamics. In this model, productivity growth is a result of an increase in the variety of new intermediate products[4] available for the final goods sector. Increased variety can be seen as providing greater opportunities for specialization, thereby boosting labour productivity. Alternatively new technology could be incorporated in new product, such that technological progress is achieved only through use of new products.

New products may be the result of own innovation effort, or they could become available through trade with other regions that are also inventing new products. Since imitating is usually cheaper, a region lagging behind the technology frontier will tend to choose this strategy. At the frontier there are simply no products to imitate. The cost advantages makes it possible for the laggard regions to grow faster than the frontier regions, but only for a period, while the cost of imitating is assumed to increase when the regions are approaching the technological level at the frontier. The decreasing cost advantage plays the same role in this model as decreasing marginal return on capital in the Solow-model. A reason for the cost to be increasing, when the region get more technological advanced is that the cheapest and easily accessible technology is adopted first. The lagging region has incentives to imitate as long as the cost of doing so (v_2) is lower than its cost of innovating (η_2).

The cost advantage increases with distance to the frontier, measured by the ratio of intermediate products ($\frac{N_2}{N_1}$) available in the laggard region (region 2) to the number of intermediates available in the region at the technological frontier (region 1). The regions are assumed share production functions, but differ in productivity parameters, A_i, and initial number of goods available, N_i, i=1,2. Assuming the production function of a Spence (1976)/Dixit and Stiglitz (1977) type, relative productivity ($\frac{y_2}{y_1}$) in the two countries can be described as a function of the relative technological parameter ($\frac{A_2}{A_1}$) and the relative

[4] Growth through increased variety of new products is based on the product variety theory of Dixit and Stiglitz (1977).

availability of intermediates ($\frac{N_2}{N_1}$) as described in equation 3.8). The cost of imitating (v_2) could be described as an increasing function of $\frac{N_2}{N_1}$ given by equation 3.9).

3.8) $$\frac{y_2}{y_1} = \left(\frac{A_2}{A_1}\right)^{\frac{1}{1-\alpha}} \times \frac{N_2}{N_1}$$

3.9) $$v_2 = v\left(\frac{N_2}{N_1}\right) \qquad v_2' \geq 0$$

The dynamics in the model works through the development of the variety ratio $\hat{N} = \frac{N_2}{N_1}$ over time, and steady-state ($\left(\frac{N_2}{N_1}\right)^*, v_2^*$) is characterized by $\dot{\hat{N}} = 0$ and $\dot{v}_2 = 0$. We see that the model predicts conditional convergence, were productivity in steady-state depends on $\frac{A_2}{A_1}$ and the steady-state value of $\frac{N_2}{N_1}$ ($\left(\frac{N_2}{N_1}\right)^*$).

$\frac{A_2}{A_1}$ can be interpreted as the regions technological capacity and is reflecting different regional policies and institutions decisive for the regions' relative productivity potential or technological capacity. Regional trade policies or policies securing a good business and investment climate are examples of such. The steady-state variety ratio $\left(\frac{N_2}{N_1}\right)^*$ depends on the relative cost advantage in imitating and the laggard regions (region 2) initial productivity (productivity potential). Initial productivity in the regions is important for the innovators' profitability, since the demand for new intermediate is increasing in the productivity of the final good sector. Initial productivity depends on the market size (L_2) and the region's technological capability in utilizing new technology (A_2). Since imitating also requires a certain amount of investments, initial profitability is important for the regions ability to finance new technology, which could get them out of the productivity backyard. If the region is not able to finance imitation of excising technology necessary to outpace the growth of the frontier region there will be no convergence.

If the cost advantage is strong enough and the laggard regions is sufficiently productive initially, the laggard country will be able to adopt new products at a more rapid rate than country 1, but the rate of imitation will slow down as the technology gap diminish and the cost of imitation cost rises. If $\dot{\hat{N}}$ reaches zero before $v_2 = \eta_{2,}$ then country 2) will remain an imitator and $\frac{N_2}{N_1}$ will tend to remain less than one in steady-state.

In steady-state the regions are assumed to grow at the same rate equal the growth rate of new innovations (γ_1). C*eteris paribus,* we see from equation 3.8) that region 2 will contain to have a lower rate of productivity. The model is similar to the neoclassical Solow model in that the driving force is decreasing returns (here to adopting technology), and that the countries are expected to converge to the same long-term growth rate. The main difference is that the process of catch-up is by no means automatic. If the investment devoted to imitation is not sufficiently high, growth in new products through imitation will be lower than the growth through innovation in the frontier region. In the model this can appear as a too low $A_{2,}$ or it could be the case if the marginal return to new products is relatively low.

Another characteristic of the catch-up story is that the range of different factors determining possible regional specific steady-states is far more complex than in the neoclassical model. In addition to the economic factors like investments in physical and human capital, so important in the neoclassical approach, social and institutional factors are crucial to the outcome. In the technology-gap literature, the concept of ‘social capability’, used by Abramovitz (1986) among others, has been used to describe a region’s ability to catch up. Important factors here may include the interaction of financial institutions able to handle large-scale investments, a stable political climate, a relatively competent workforce and openness to trade.

Whether regions that start out with less advanced and less productive technology will converge to the innovative frontier depends on the nature of the technological spillovers involved. The Barro and Sala-i-Martin model do not geographically restrict the externalities, but such an effect of increasing cost of imitation with distance could be caught up in the technological capability parameter A. Thus longer a region is from the frontier thus smaller A.Local externalities and regional heterogeneity in production structure are likely to give rise to economic clusters and economic agglomeration.

3.3 Market access and economic agglomeration

In a market economy, profitability determines where the firm chooses to locate. Here, local externalities and/or the size of the market may be important determinants. Externalities linked to the local amount of human or physical capital and/or the number of firms in the market will increase the profitability of being located in that area. Examples of such externalities are learning effects from production or investments in local, which boosts the general technological competence of the local workforce or pecuniary externalities, which are externalities working through the market. The latter argument has been formally developed by Krugman among others (Krugman 1991, Krugman and Venables 1990). The central point in this theory of agglomeration is that the industries with economies of scale in production have incentives to locate in proximity to the relatively larger markets in presence of trade cost.

Given the existence of economies of scale, the firms will face a trade-off between being able to make use off gains from being located in one market and the loss from trade costs. If the trade cost (eq. transport cost) is relatively large the firms will find it more profitable to be located in ‘both’ markets. At the other hand if the trade costs are sufficient low location does not matter. For an intermediate level of trade costs, being located in the largest market is for a firm most profitable. This is just a part of the story. In addition the market size is increasing in the number of firms located there, which increases the profitability of the location. It is the interaction between these factors that drives the agglomeration dynamics.

The market could increase in number of firms, because the goods produced by one firm are used as intermediates in production by other firms, as in the model by Krugman and Venables (1990). Another 'centripetal' force, as emphasized in Krugman's core-periphery model, is migration (Krugman 1991). Number of firms located in a market will tend to increase the goods available. In existence of trade costs will the market with a relatively larger number of firms offer a relatively larger amount of goods to a lower price. The availability of relatively cheaper goods gives people incentives to migrate to the relatively larger market. Number of people moving to a market increases the demand facing the firms, such that the firms located there by utilizing the economies of scale, become even more productive. Several firms find it then profitable to move to the center.

The centripetal forces in Krugman's core-periphery model, and as well the model by Krugman and Venables (1990), are likely to give a geographical pattern with one or several economic cores, characterized by relatively higher productivity level and growth, spread over the country. According to these model and related theories, we will expect to see a positive impact from an indicator on market access.

In Russia the transport costs were kept artificial low to sustain a peripheral and disperse production structure. During the transition the transport costs have increased substantial, although still low compared to in other countries. Having initially larger markets could then have been, according to Krugman's core-periphery and related models, an advantageous for Russian regions during the transition, when the transport cost started increasing. At the other hand other trade costs has decreased, at least in the recent years as a result of Putin's effort to unify the Russian national market.

3.4 Trade, industrial structure and the resource curse

Regional structure, has in the tradition of new trade theory, been emphasized as important for the result of convergence. This literature departs from the traditional trade theories, were specializing in the sectors in which the region has comparative advantage can only yield gains. In the theory analyzing dynamic comparative advantage advantages in an industry can be developed through experience, such that history matters. Since different sectors may hold different growth potential, building up comparative advantage and specializing in the 'wrong' industries may reduce a region's growth prospects. The regions happened to specialize in dynamic industries with large growth potential will at the other hand outgrow other regions. In this context the resource sector has attracted special interest, because of the large resource rents. These rents could generate adverse incentives and/or suppress other productive sectors. Growth prospects in a sector could be determined by access to sector specific factors, market potential or potential for technological growth.

The industrial structure in Russia is marked by the central planning of the past, and industrial location has been less connected to regional comparative advantages and profitability considerations. The result of this central planning was mono industrial clusters geographically scattered around the country. According to Krugman's core/periphery models, this is now likely to change. On the other hand, Russia's regions could have gained experience in the sectors and in that way developed a kind of comparative advantage in production, which could counteract such centripetal forces working in the core/periphery models (Krugman 1991, Krugman and Venables 1990).

The resource sector constitutes most of Russia's export, which have given rise to concern for two reasons. First the large resource gains can suppress dynamic gains because of reduced incentives to invest in long term productivity gains. Second large oil and gas export may lead to appreciation of the Rubble, which remove other sectors from their competitiveness. Possessing large resource endowments may therefore be either a blessing or a curse. Empirical findings show that economies with an abundance of natural resources tend to grow more slowly than those without (Sachs and Warner 1997). The argument is that the large resource rents spur a kind of rent-seeking behaviour among entrepreneurs and politicians, and that the resource sector over time could suppress other productive sectors. Mehlum, Moene and Torvik (2002) argue that whether this is the outcome depends on the quality of the institutions that govern the economy. ‘Producer-friendly’ institutions may manage to take advantage of the resource gains. The rents could invest in subjects increasing productivity of other sectors, yielding long-term gains. A productive resource industry could also stimulate demand in the manufacturing industries and/or be a supplier of intermediates to the final producers, as has been found to be the case in Russia (Bradshaw 2006).

3.5 WHAT KIND OF CONVERGENCE?

Convergence is a transitory phenomenon, describing the growth dynamics towards regional specific steady-states. Both the neoclassical and catch up theory, like that derived by Barro and Sala-i-Martin (1997), predict conditional convergence. In the traditional neoclassical approach, the steady-state was characterized by a few factors representing the consumers’ time preferences, growth in the workforce and the rate of capital depreciation. One branch of theories has aimed to describe the plurality of characteristics of different steady-states. Inspired by endogenous growth theory, a whole string of factors has been included in convergence analysis. Only in the case of equal regions, in the sense of common steady-states, is convergence expected. It could be argued that absolute convergence is more likely to occur across regions than across countries, because the former share a set of legal, economic and political institutions as well as language, a set of cultural codes and, in the case of Russia, a common socialist past. On the other hand, however, we should note that Russia’s regions differ considerably in terms of geography, climate and industrial structure.

4. DESCRIPTIVE ANALYSIS

Russia is the largest country in the world, its 17.1 million km^2 covering almost half the Northern hemisphere and, extending from China and Japan in the east to Western Europe. It can boast an enormous variety of landforms and landscapes: arctic deserts in the extreme north, tundra and large forest zones covering about half of the country, as well as the fertile areas in central European Russia, bordering on Ukraine and Belarus. This gives large variation in natural resource endowment, as well as in climate and communication possibilities. In addition, the highly diversified industry, much of it off-centre, makes Russia unique, and constitutes a natural starting point for examining the regional differences in productivity growth.

4.1 Russian regions

Today Russia consists of 83 regions, divided into five categorises: oblast, republic, krai, okrug and federal cities. (See Fig. 4.1) These subjects have differing degrees of autonomy. Oblast is the most common form of federal subject. Krais are basically the same as oblasts, but are generally located at the frontier. The 21 republics have traditionally enjoyed a higher level of autonomy than the other regions. The okrugs are considered to be administrative divisions of other federal subjects, except for Chukotka Autonomous Okrug in the extreme northeast. Since the okrugs, except Chukotka Autonomous Okrug, are reported together with the subjects, who they are subordinated, this gives me 79 regional observations.

Figure 4.1*: Russia's regions:*
http://upload.wikimedia.org/wikipedia/commons/3/37/Russian-regions.png

4.2 Productivity

In 1996, output per worker was 25 times higher in the most productive region (Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets) compared to the region with the second lowest output per worker (Dagestan republic). Ingush republic was recorded as being by far the least productive, but the observations seem unreliable: both productivity level and growth vary extremely from year to year. I will therefore report summary statistics excluding that region.

The highest level of labour productivity is to be found in the Urals and eastern Urals – which are substantially endowed with natural resources: oil, gas, metals and forests.5 This area is shaded dark shaded on the map in Fig. 4.2, which shows the geographical distribution of

[5] Following Bradshaw (2006), I define resource production as production in the fuel, metal and timber, woodworking and pulp/paper industries.

productivity levels in 1996. The maps are divided into four equally large productivity intervals, with darker shading after productivity. The picture looks almost the same for 2004 (Fig. 4.3).

Figure 4.2. *Labour productivity 1996.*

Figure 4.3. *Labour Productivity 2004. Source: Goskomstat, regional statistics.*

When comparing the ranking of productivity rates in 1996 with 2004, I found that productivity rankings have remained quite stable. Spearman's rho, which measures the ranking correlation, is 0.808. Scatter plot (Fig. 4.4) plot the productivity levels in 1996 against the productivity levels in 2004. From the scatter plot diagram (Fig. 4.4) we see that high productivity level in 1996 is associated with a high productivity level in 2004. The plot show no clear signs of convergence. There are some vague signs on movements in the relative distribution of productivity rates among the initial middle to above middle productive regions, were some regions have managed to grow, while others have dropped in productivity. A group of initially least productive seems also to have lagged behind. Looking at the top five productive regions in 1996 compared to 2004, we see some movement in the ranking, but the two most productive – the resource-rich regions of Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets and Sakha (Yakutia) republic – have retained their positions. The ranking of the bottom five remains the same in both years. (see appendix A.4)

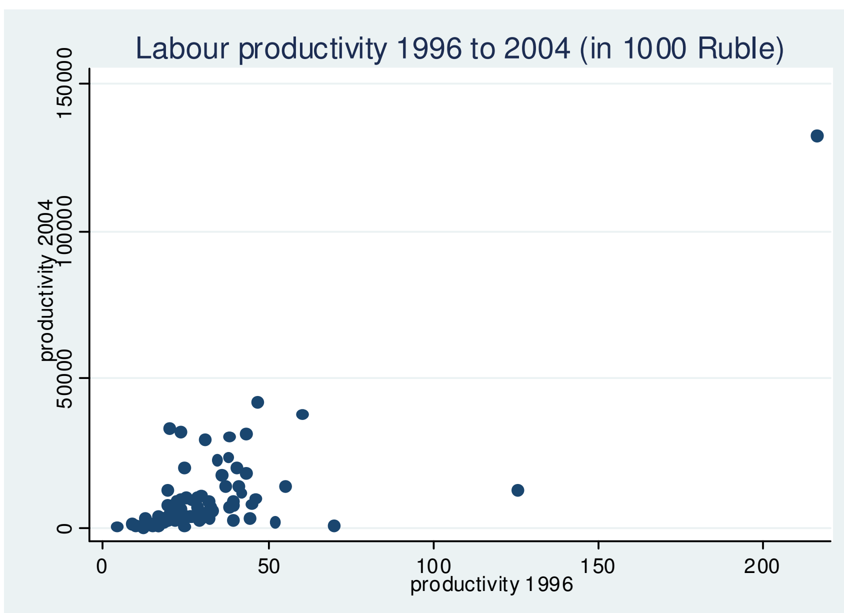

***Figure 4. 4**. Labour productivity level in 1996 compared to 2004. Source: Goskomstat*

Regional output per worker has increased by almost 60 percentage points on average from 1996 to 2004, but regional growth performance has differed substantially. While some regions can note significant productivity growth over the whole period, others have experienced negative growth rates: in four regions, labour productivity fell during the period. Omsk oblast, one of the regions, was hard hit by the financial crash in 1998, and its manufacturing industry was almost halved.

Figure 4.5) shows the regional distribution of average growth rates for the period 1996 to 2004. While the map with productivity levels showed a clustering pattern in the resource belt, regions with the highest growth rates are scattered around the country. The resource-rich regions do not stand out here. Despite sharply rising oil prices from 1998, only some of the regions with substantial oil and gas production, like Sakhalin oblast and Arkhangelsk incl. Nenets, have had relatively high average growth. Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets shows only moderate growth performance. The two main financial centres, St. Petersburg and Moscow, were among the regions with relatively high growth rates.

Figure 4.5: *Average regional productivity growth 1997–2004. Source Goskomstat.*

4.3 Regional distribution of resource intensive production

Most of Russia's resource rich regions are to be found in what is referred to as the Russian North (Blakkisrud 2006). Timber and cellulose production are largest in the north-west, Karelia republic and Arkhangelsk incl. Nenets. Khanty-Mansijskn is the major oil-producing region, while most of Russia's gas production takes place in Yamalo-Nenets, both included in Tyumen. Most metal production is located in the Far East and East Siberia, with Sakha (Yakutia) republic as the major metal producer. The maps in figures 4.6) to 4.9) show the regional distribution of the natural resource industries, fuel, metal and timber, woodworking, pulp and paper, in 1997. The resource maps are as the productivity maps divided into four equally large productivity intervals, with darker shading after productivity. Figure 4r to as the resource industry. From the four maps it is clear that natural resource industries as a share of regional industry production are largest in the more peripheral parts of Russia.

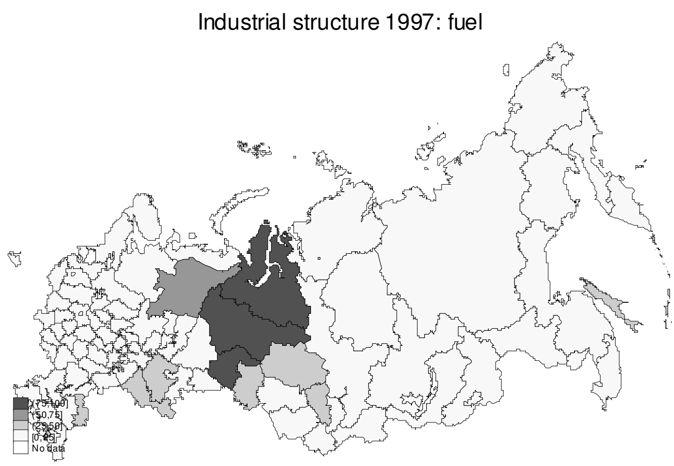

Figure 4.6: *Regional share of fuel industry in production*

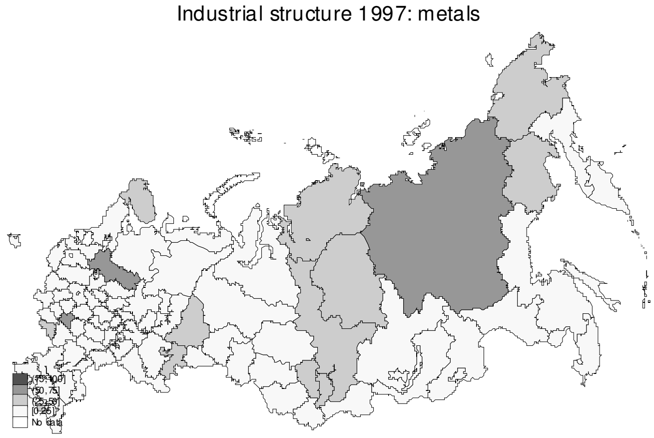

Figure 4.7: *Regional share of metal industry in production*

Figure 4.8: *Regional share of timber, woodworking, pulp and paper industry in production.*

Figure 4.9: *Regional share of natural-resource-intensive industries in production. Source Goskomstat*

Russia is basically a resource-based economy, where the sectors stand for a large part of value added in Russia and almost all of the export revenues. The resource sector accounted for roughly 70 % of the growth in industrial production from 2001 to 2004, with the oil sector alone accounting for slightly less than 45 % (Ahrend 2006). The large resource endowments have given Russia high value-added production and created a sort of economic centre in the more or less peripheral areas of the country.

5. Empirical analysis

In this chapter I investigate how relative productivity levels across the regions of Russia have developed during the period 1996–2004. Is there evidence of convergence or divergence in productivity levels? With productivity I have labour productivity in mind, defined as value-added industrial production per employee. My focus will be on what has been traditionally regarded as Russian industry – oil and gas extraction, electricity production, mining and quarrying, and manufacturing. I will refer to these sectors simply as 'industry' or the industrial sector, in contrast to the service, transport or communication sector.

The industry sector differs from other sectors in the Russian economy in its linkages to the Soviet past. By the end of the Soviet era, the Russian economy was already heavily industrialized, whereas the service and communication sector have largely developed during the transition. Assuming that history matters for further development, this makes this sector highly interesting when analysing the hypothesis of convergence in productivity. After years of central planning, productivity rates diverged greatly across as well as within sectors, and many regions had become highly specialized in one or two sectors.

The year 1996 can be considered as the year when the economy started stabilizing under the new conditions. Since I am interested in how the distribution of productivity levels has developed in a market economy, this has been chosen as the first year of analysis. I focus on how the market forces have affected the distribution of productivity rates across Russian regions.

Have investments and technology flowed into the least capital-intensive and less technologically advanced regions, such that the initially less-productive regions have caught up with the relatively more productive ones, – as predicted by the neoclassical and technology-gap models related to new growth theory? How important are regionally specific factors for this result? Is the initial industrial specialization of the Russian regions important for the outcome, or are factors – like a good business and investment climate, openness for trade and good market access – more decisive? Will we find a tendency for agglomeration, as predicted by the Krugman (1991) model? What role do natural resources play in the Russian economy – are they a blessing or a curse for the regions highly dependent on them? To answer these questions I will do a convergence analysis, testing the impact of initial productivity on the average growth rate during the period. I will also control for the impact of certain regional specific factors, which can be highly relevant in determining regional convergence/divergence in Russia. To do this I will carry out a cross-regional analysis including a set of control variables. I will also perform a fixed-effect panel regression and compare the results. The first part of the chapter presents a discussion of methodology and choice of model and variables, while the results of the analyses are discussed in the last section.

5.1 The concepts of convergence

There are two main concepts of convergence: β- and σ-convergence. If the initially less-productive regions tend to grow faster than the more productive regions, given regional specific factors, we have β-convergence. If we observe decreasing disparities in productivity levels over time, we have σ-convergence. It can be shown that β-convergence is a necessary, but not sufficient, condition for σ-convergence[6].

Even though we get support for β-convergence, in the sense that less productive regions tend to grow faster than the more productive ones, this does not necessarily reflect convergence as predicted by the Solow model or the technology-gap model of Barro and Sala-i-Martin (1997). It could be that less-productive regions grow faster, overtaking the productive leaders, such that over time large differences will remain, only with a shift in the leaders. This phenomenon, also known as 'leapfrogging', has been analysed by Brezis Krugman and Tsiddon (1993) among others. I will analyse σ-convergence to see whether the dispersion in the labour productivity levels is increasing or decreasing over time, but the main focus will be on β-

[6] The equations for β- and σ-convergence derived from the Solow model are presented in appendix 5.1, where I show more formally how the concepts are related. Interested readers are also advised to consult Barro and Sala-i-Martin (2004).

convergence. I will test for β-convergence, in order to determine whether there is a tendency for less productive regions to catch up with initially more productive regions.

5.2 The model

The empirical literature on convergence analysis has tended to use cross regional data, whereas a panel-data approach has become more and more common with increased data availability, where Islam (1995) and Caselli et al. (1996) among others have contributed to the work. The cross-regional approach has been criticized for inconsistency due to omitted variable bias and that at least some of the explanatory variables are endogenous (Caselli et al. 1996). Omitted variables could typically be inter-regional differences in technology, politics, culture and climate, which are not always observable. Since I have panel data it may be possible to remove the region-specific effects, including non-observable events, with model utilizing the variation over time as well as regions. The weakness is that the time intervals for which the growth rates are calculated over become shorter. This leads to estimates that are more sensitive for cycles around the trend. Only eight years are covered in my time series, which yields at most two four-year periods. As that the fluctuation has been substantial over the years in Russia, I will base my analysis on the cross-regional approach and use the results from the panel analysis as robustness check.

Cross-regional regression

To test for convergence I employ a linear model with average growth (ag_i) as a function of log initial productivity level ($\ln(cind_{i,1996})$) and a set of explanatory variables, given by the matrix (X_j). Equation (5.1) defines the model to be used in the cross-regional analysis, while equation (5.2) describes how I have calculated the average growth rate.

(5.1) $$ag_i = \alpha + b\ln\left(cind_{i,1996}\right) + \sum_j \lambda_j X_{ij} + \varepsilon_i$$

(5.2) $$ag_i = \frac{1}{8}\sum_{t=1997}^{2004} g_{i,t}$$

b in eq. 5.1) is the convergence coefficient, α is the intercept, assumed common to all regions, ε_i is the regional-specific error term, and λ_j represents the coefficient on the j control variables (X_{ij}). A negative b implies that regions with relatively initial lower productivity level in general have higher average growth rates over the period analyzed, so a negative b supports the hypothesis of convergence.

The Solow model and the technology-gap model of Barro and Sala-i-Martin predict a negative sign on b, while α is assumed to be positive and to capture the common steady-state factors, including the long-term growth rate. Krugman's core/periphery model predicts a positive sign on b and opens for the possibility that α also can take negative values. According to the recourse curse argument we should expect to see a negative sign on $\lambda_{resources}$, but the sign of b is not predicted, even though, since the initial most productive regions are the recourse rich regions, a negative sign on b could be reasonable to predict.

The average growth rate (eq.5.1) is calculated from the yearly growth rates ($g_{i,t}$) from 1997 to 2004. This approach is somewhat different from that of the Barro and Sala-i-Martin regression (1991, 1992). Barro and Sala-i-Martin use the log of the end observations, the observations measured in the first and last years of the period analysed. This renders the average growth rate sensitive to possible cycles in these two years. To make the measure of the productivity growth trend more robust for cycles in the end observations, I take the average of the yearly regional growth rate. This is in general a more robust average. On the other hand, my measure is more sensitive to the large regional fluctuations in growth rates in the years after the financial crisis of 1998. So by comparing my result with the outcome, when using Barro and Sala-i-Martin's method for calculating the growth rate, I can get an indicator of whether my results are sensitive to the fluctuations in the years after the financial crisis.

Variables to include in the analysis

There is no single answer to which control variables to include in the analysis. It all depends on the theory approach and characteristics of the area of interest, as well as data availability.

Based on the theory models presented in chapter 2 and what is deemed important for regional growth in Russia, I will include several state variables in the analysis.

The classical factors derived from the Solow model are the rate of population growth and the share of production used in investments (investments), as well as investment in human capital (human capital). Investments in real and human capital are expected to have a positive impact on average growth in the regression, since higher values are assumed to determine higher steady states, while population growth is expected to have a negative impact. Capital investments have proven empirically important in explaining different steady-states.

Variables related to endogenous growth theory are research and development (R&D), reflecting the regional rate of innovation, together with trade and foreign direct investments (FDI) as a share of the regional economy (FDI). The share of trade and FDI in the economy (trade and FDI) could reflect a region's access to foreign technology. To capture possible national spillover effects I have included a regional 'spillover' variable (spillover). I also include a market potential variable (market potential), which describes another form for positive externalities, working through the size of the market. This variable is meant to capture the crucial mechanism in Krugman's core/periphery model.

Both settlement patterns and industrial location are influenced by the regional politics practised under the Soviet Union. The migration potential today may be considerable. In Russia, migration has followed two patterns: people move for job opportunities, and for a better climate. Migration is expected to have positive and negative effects in a growth regression, depending on the theory perspective. In the Solow model, the rate of migration is expected to accelerate the speed of convergence, while the flow of immigrants in the Krugman's model increases the size of the market and thereby results in increased divergence. To capture both effects I will test for the effect of migration share (migration share) as well as total flow of net migrants (migration).

Variables of regional industrial structure are commonly used as control variables in analysing convergence among regions within a country (see for example Barro and Sala-i-Martin 1991 or Ahrend 2002 for the case of Russia). Major differences in industrial structure could be a barrier to technological catch-up. Since the regional differences in industrial structure in Russia are large, I will include structural variables in the analysis to test whether industrial composition is important for regional productivity growth and whether the different structure could be a barrier to convergence[7].

Given Russia's economy and especially the dependence of some peripheral regions on natural resources in production, and the attention this has in economic literature, I will include the resource-variable (resources). This consists of the regional shares of fuel, timber, woodworking and the pulp- and paper and metal industry in production. Depending on the quality of the national and regional institution, the resource variable is expected to have positive or negative impact on growth. Thus this variable could also reflect institutional quality. Concerns have been voiced about the oil and gas sector, but I maintain that the "resource curse" argument applies to all sectors that are based on highly valuable natural resources with opportunities for easy gains. Even though the oil and gas industry is responsible for much of the revenues generated in the Russian economy, for some regions other sectors and resources, such as metals, diamonds and forest products, are a substantial source of revenue. The large fortunes from these commodities are a determining factor for a number of resource regions (Bradshaw 2006).

Political and institutional differences, such as type of regime (often degree of democracy), rule of law and investment and business climate, are often assumed away when analysing convergence among national regions. It could be argued that regions within Russia are more equal than regions across different countries. On the other hand, regional policies during the 1990s were fragmented and largely diversified in their reform performance, although in larger extent subordinated federal politics after Vladimir Putin came to power in 2000. What has been the successful political strategy during the transition has been hotly debated. Many authors have analysed the effect of reform-friendly policies, including the degree of price

[7] The industry sector used in the analysis are described in the appendix (A.5.2)

liberalization and privatization, on economic performance, but the results are not clear.[8] I will use the formation of small and medium-sized enterprises[9] (SME) as an indicator of regional investment and business climate. SME formation can be considered as roughly equivalent to the number of new enterprises. The 'openness'" indicators (trade and FDI) could also to some degree reflect market-friendly policies.

A full list of the included variables and a description of how they are constructed are attached in appendix 4.2. Some variables require extra attention as to their construction and quality as indicators. I will go through them in the following. Issues more directly related to the quality of the data will be discussed in a separate section (5.3).

The variables under closer consideration

The average educational level in Russia is high, so I will use the share of employees with a bachelor degree or higher (human capital) as an indicator of investment in human capital in Russian industry. A more common indicator has been, following Mankiw, Romer and Weil (1992), the enrolment rate of secondary schooling, but this level of education could be too low to make any difference in the case of Russia. Given the good education system, most people in Russia can be assumed to have completed secondary schooling.

The market potential for a firm is not restricted by the size of the economy of the region in question, but also the size of the markets in surrounding regions. A firm's market potential is assumed to decline with distance, due to the presumed increase in trade costs. To measure region i's market potential I take the sum of the gross regional product (GRP) of all the regions, including regions i's GRP, and weight by the distance to region i. The distance between regions calculated by taking the great circle distances between the capitals.[10] There is one important weakness with my calculations: foreign markets are not included. This probably

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[8] Berkowitz and DeJong 2001, Popov 2001 and Ahrend 2002 are just a few examples

[9] SME is defined as an enterprise employing fewer than 250 people.

[10] For a formal description of the *mp* variable see appendix (A.5.2).

gives the variable an eastward and inward (domestic) bias. The variable does not include the possible positive effects of being close to large foreign markets. The result is an underestimation of the effect of being located in central federal district or as well at the border to other Asian markets in the east.

To capture the possible effect of inter-regional spillovers within Russia I have constructed an indicator (spillover) of technological transfer, similar to the market access variable, using the other regions' productivity level instead of GRP. This indicator is based on the assumption of increased geographical proximity for the channels for technological spillovers in general, as trade and inter-regional investments.

I have included the share of employees employed in R&D activities as an indicator of regional innovative capacity or innovative production in a region. Some uncertainties about how well this indicator reflects innovative capacity in the Russian regions may remain. In Russia, despite relatively high inputs in R&D activity, output is generally disappointing, with little commercial potential. Most activities are run and financed by the state, while private-sector involvement in R&D is limited (Gianella and Tompson 2007). All the same, I have chosen to keep the innovation variable. At least I cannot rule out that hosting research institutions could generate some sort of positive externalities. Therefore I consider it better to include the variable, despite its flaws.

My list of control variables is far from inclusive. Basically, I have selected those variables where reasonably good indicators are available. For many regional features it is difficult or even impossible to create reliable indicators. Especially political, cultural and institutional differences are hard to capture. In addition I have not been able to create a variable that captures the effect of being close to foreign markets. It could be argued that all these features change slowly over time, or at least the relative pattern between the regions remains approximately the same in time. Fixed-effect panel regression could therefore possibly control for these effects. I will therefore carry out a panel analysis to check the robustness of the convergence analysis.

Panel regression

A fixed-effect panel regression is intended to control for all factors that vary across regions but remain fixed over time. By applying this method I test for a sort of conditional convergence. A negative sign on the convergence coefficient (b) implies convergence, conditional on all factors determining the different regional steady-states.

I will do a 'before and after' analysis, which is a type of fixed-effect regression with two time observations (Stock and Watson 2003). By dividing the dataset into two equal time periods (1996–2000 and 2000–2004), I get two equal equations for convergence (5.3), one for each sub-period τ ($\tau = 1,2$). Initial productivity for the first and second periods is measured in 1996 and 2000 respectively, and the growth rates are the four-year average for each period. By subtracting the equation for period 1 from period 2, I get a difference equation (5.4) that expresses the change in average growth as a function of the change in productivity level.

5.3. $$ag_{i,\tau} = \alpha + b\ln\left(cind_{i,\tau}\right) + \sum_j \lambda_j X_{ij} + \varepsilon_{i,\tau} \qquad \tau = 1,2$$

5.4. $$ag_2 - ag_1 = b\left(\ln cind_{99} - \ln cind_{96}\right) + \left(\bar{\varepsilon}_{i,2} - \bar{\varepsilon}_{i,1}\right)$$

By focusing on changes over time I have removed the factors that differ over regions, but are fixed over time. Theoretically this implies that I control for all regional characteristics determining steady-states, since these factors are assumed to remain fixed over time.

What has been found important for regional economic performance?

Several analysis of convergence in GRP per capita has been carried out, but as far as I know few have focused solely on the industrial sector. Industrial structure, resource endowment, human capital, market access and political and institutional factors have emerged as important for regional growth in GRP per capita, but the evidence differs. Maurseth (2005) and Östreich-Nielsen (2005) find evidence that being close to large national markets or having large resource endowment is favourable for regional growth. Ahrend (2002) finds that initial industrial structure, endowment of natural resources and human capital had large impacts on economic growth performance during the 1990s. Also Dolinskaja (2002) derives a similar conclusion, with findings that confirm the importance of industrial structure and natural resources in explaining regional differences in growth rates.

5.3 The Data

The analysis is based on regional data from Goskomstat, which issues the official statistics in Russia, for the period 1996–2004. This gives me a balanced panel with 8 yearly and 79 regional observations for growth and productivity level.

Although technically correct, the Russian data suffer from reporting problems. Price statistics are often regarded as unsure, and views have differed as to whether it is preferable to use the official price statistics on deflation or not. It seems reasonable to believe that the statistics have improved since the consumer price index (CPI) was issued for the first time in 1992. Regional price statistics has only been issued recently. I have regional price statistics for the whole period reported in 2005 and 2006, which enables me to adjust for regional price differences over time. Despite their weaknesses, the regional price statistics for the industry are the best price indicator available and I will use them in deflation of the data. Assuming that the measurement error is equally distributed across regions, using a deflator based on these statistics will not cause any bias.

Another potentially significant source of bias is the under-reporting of value added in the industry sector. Much of the value added generated in industry is reflected not in the accounts on the relevant industrial sector, but in the accounts of affiliated trading companies. Reduced tax is a strong motive, but there is to some extent a logical form of organization for products whose export and home market prices differ substantially (Ahrend 2004b). If the bias had been equally distributed across regions, it would not constitute any problem for the analysis. The problem is that this practice applies to certain sectors – natural resources in particular –

and when output is exported, which could have consequences for the observed regional distribution of productivity levels.

According to World Bank estimates, value added from oil and gas production in GDP was under-represented by 11.4% in the official statistics in 2000 (World Bank 2004). This practice cannot be assumed to be constant over time, and the extent of this problem in 1996 can not easily be quantified. However, the risk that the reported value added in the large oil and gas producing regions is under-reported in 1996 is substantial. If the extent of under-reporting changes over time, that could also bias the observed regional distribution of growth rates.

One way of circumventing this problem is to use production volume instead of value added. The measures are strongly correlated and in an analysis of productivity in several sectors of the Russian industry, Ahrend (2004) found that the results of using either measure were qualitatively similar. I will use value added in my analysis, since it is a more exact measure when analysing productivity.

The problem of under-reporting value added in industry could cause some bias also in the trade data, since the problem especially concerns the resource industries and exporting sectors. If affiliated trade companies are located in other regions than the producers of the output, this will undermine the extent of trade in the producer regions. The importance of this potential bias is hard to estimate, but is probably less than the bias in value added.

The observations on FDI are rather doubtful. A substantial part of the FDIs are actually Russian investments that have been on a ‘round trip’, and are not real foreign investments. The result is that the FDI variable also partly reflects Russian investments.

Despite the flaws in the trade and especially the FDI data, I consider the variables on share of trade and FDI in the economy as important for my analysis. The adoption of existing technology has proven to be a common form of innovative activity in Russian firms, while foreign competition provides incentives to innovate and invest in increased productivity among Russian firms (Kozlov and Yudaeva 2004). The 'openness' variables could therefore be important catching-up regional features connected to the technology-gap hypothesis.

Missing values

In general there are not many missing values, but some regions and variables stand out. For the regions Chechnya, Chukotka autonomous okrug and Ingush republic, some observations are missing. Several observations are missing for the industrial employment and structure variables. With Chechnya, observations are lacking on almost all variables, so I have chosen to remove Chechnya from the sample. Moreover, the region has been destabilized for a long time, and in that sense represents an outlier. For the other republics and variables I have enough information to extrapolate the missing observations. A description of which observations have been extrapolated and how is found in appendix (A.5.3).

Data for Ingush republic seem afflicted by reporting bias in general. Observed values for several of the variables used in my analysis show large annual fluctuations for this region. Observed values on industrial structure, output per employee and investment fluctuate enormously from year to year. At the extreme, investment is reported as increasing by a factor well beyond 100. Such fluctuations can only to some extent be explained by the small size of the Ingush economy.

5.4 Econometric issues

For the regression and statistical calculations I have used the statistical programme package Stata/SE 10.0. I base my analysis on an ordinary least-square regression (OLS).

I will use observations from the first year of the period for the right-hand variables, to reduce the risk of problems connected to simultaneous causality. The variable for labour productivity was observed in 1996. Observations on my control variables were measured in 1996 (1997),[11] when possible. Only the variable for investment in human capital was observed in the middle of the period under study, whereas observations for investment in human capital are only available for 2000.

Distribution of the data

Figure 4.4.1. gives a picture of the distribution of average growth rates, conditional on initial productivity (1996). Most observations appear clustered around a slightly downward sloping line, but three observations stand out. The observation in the upper left corner represents the Ingush republic; the point furthest to the right is the oil- and gas-rich region of Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets, while the observation second to the right is Sakha (Yakutia) republic, a region with considerable metal and mineral resources. Especially the Ingush republic can be regarded as a potential outlier – an assumption supported by the large annual fluctuation in the observations for that region. Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets and Sakha (Yakutia) republic have by far the most resource-intensive production.

[11] For some of the variables I use 1997 observations, in the absence of 1996 observations. In the variable table in appendix (A.5.2) I have noted the year observed.

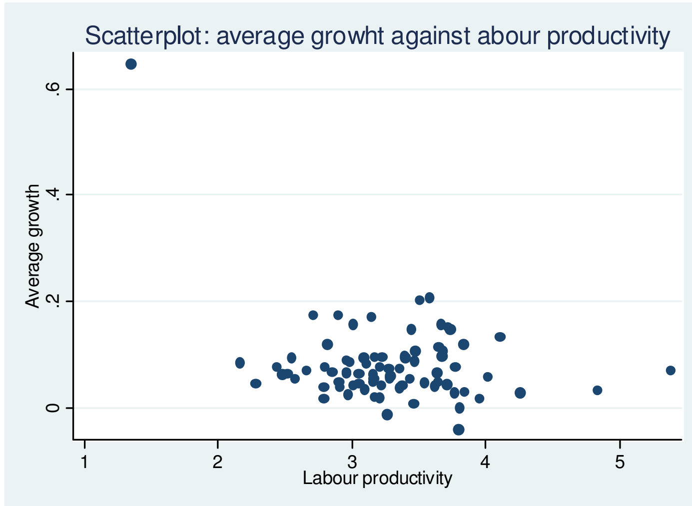

Figure 5.4. 2: *Average growth 1997–2004 versus productivity level in 1996*

Since the OLS estimators are sensitive to outliers I will control for the three outlier regions in the analysis. I will in the absolute convergence analysis run a regression with regional dummies, but also one when the Ingush republic is omitted from the sample. In the multiple regression analysis, testing for conditional convergence, I will drop the observation on the Ingush republic and assume that the resource variable accounts for much of the effect from Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets and Sakha (Yakutia) republic.

The dummy for the Ingush republic (d_Ingush) is highly correlated with the share of trade in the regional economy. The correlation coefficient is 0.945, which might mean problems with multicollinearity. In general, correlation between the variables is not a problem for the analysis and the OLS estimators are still valid under imperfect multicollinearity. When the correlation between two explanatory variables is high it results in less precise estimates and the test statistics become less reliable. Only a few variables in addition to d-Ingush have substantially high correlations. The variable for the share of people employed in R&D is highly correlated with the variable for market potential, education and especially total migration. Market potential is also substantial (corr≥2/3) correlated with spillover and migration. Not surprisingly, the resource variable is highly correlated with initial productivity.[12] The correlation matrix below shows the correlation between selected samples of variables; the full correlation table is presented in appendix 4.4.

The financial crisis

The financial crisis of 1998 could be important for the analysis, for two reasons. First it has been argued that the years following the crisis, including the regime shift in 2000, represent a potential shift in the Russian economy, possible changing the importance of the underlying forces in the economy (see for example Maurseth 2005, Nielsen 2005). Second the financial crisis was an economic shock, so the growth rates in the years immediately before and after may not reflect real economic change.

As mentioned, comparison with the regressions based on the Barro and Sala-i-Martin growth rates will give an indication of the robustness of my results for the fluctuating growth rates after the financial crisis, since their estimate do not include the growth rates from those years (Barro and Sala-i-Martin 1991, 1992).

The cutback in the large federal subsidies to the industry, made necessary by the massive governmental deficit, and the fiscal reform from 2000 aimed at making federal transfers more coherent, can be argued to remove some of the barriers to convergence. On the other hand, the simultaneous oil price increase could work the other way around, reinforcing the already sizable difference between the ‘resource regions’ and the other regions. Maurseth (2005) and Östreich Nielsen (2005) found that fuel and energy became more important in explaining differences in growth rates after 1998. Because of the short time period, and the large fluctuation in the growth rates also in the years after the financial crisis, I will not put any focus on dividing my regression into several periods.

[12] A correlation table for all the variable in the analysis, except the variables for the different industry sectors is attached in the appendix. No of the sector variables are however highly correlated with any of the other variables.

5.5 Empirical results

From my descriptive analysis I found that the largest resource-rich regions were by no means the most productive, whether in 1996 or in 2004. I also found that the productivity ranking was quite stable, especially at the bottom. The five least productive regions in 1996 were the same in 2004. Even though the ranking has remained quite stable, the productivity differences between regions could have decreased. Whether the regional productivity rates have converged or diverged from 1996 to 2004, and dependent on which factors, is what I will try to answer next.

Absolute convergence

The test for absolute convergence supports neither convergence nor divergence among Russian regions. The convergence coefficient, b, has in general a slightly negative sign, but is definitely insignificant. When controlling for potential outliers, the effects of initial productivity on growth disappear.

The results are presented in Tab.5.5.1. The first row shows the basic regression, R1, on a full sample without any regional dummies. In regression 2, R2, I have included a dummy for the Ingush republic (d_Ingush), potential outliers. I have also tested the effect of including dummies for additional two potential outliers, the resource regions Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets (d_Tyumen) and Sakha (Yakutia) republic (d_Sakha), in the regression. These results are found in appendix (A.5.5). In regression 3, R3, I have removed the Ingush republic from the sample. In the final regression (R4) I have tested the hypothesis of convergence on the 2/3 initially richest regions.

The convergence coefficient is slightly negative, but not significant in either of the regressions. Controlling for potential outliers further reduces the significance of b. Only the dummy for the Ingush republic (d_Ingush) is significant, while the two other regional dummies do not show any significant effects on the result. Including a dummy for Ingush republic (d_Ingush) increases the explanatory power considerable. This large increase, because of controlling for one observation, is disturbing, and provides a strong argument for removing Ingush republic from the sample. When the observations for Ingush republic are removed from the sample, R-square drops.

	Absolute convergence							
	R1		**R2**		**R3**		**R4**	
Obs	79		79		78		78	
R-squared	0.1087		0.6433		0.0014		0.0013	
	Coefficient	**P>|t|**	**Coefficient**	**P>|t|**	**Coefficient**	**P>|t|**	**Coefficient**	**P>|t|**
lncind	–0.0467	0.2300	–0.0034	0.6860	–0.0034	0.684	–0.0043	0.7040
constant	0.2340	0.0800	0.0853	0.0020	0.0853	0.002	0.0883	0.0320
d_Ingush			0.5670	0.0000				

Table 5.5: *Testing for absolute convergence*

Regression (regr4) shows results of testing the hypothesis on convergence on the 2/3 initially richest regions. The rationale for this is that the least productive regions could stand out when it comes to convergence. In the Barro and Sala-i-Martin (1997) technology-gap model there could exist a threshold for where the gap between the least productive regions and the technology developed and advanced regions is too large. A possible outcome is then that the laggard regions are simply left behind. I have found that the productivity ranking is quite stable for the initially least productive regions, when comparing their productivity rank in 1996 against their rank in 2004. Regression 4 does not support the hypothesis of higher convergence among regions that were more similar in terms of initial productivity. I have also looked if there is any sign of convergence among the 1/3 least productive. The convergence coefficient is significantly negative, but the sign of convergence disappears totally when the Ingush republic is controlled for. Results from this regression are presented in appendix A.5.5.

There are in general no signs of either absolute convergence or divergence in my data.[13] The OLS estimator appears quite sensitive to the observation for the Ingush republic and the explanatory power increases disturbingly when a dummy for Ingush republic is included. I will continue to test for conditional convergence, as argued, without the Ingush republic in the sample.

Conditional convergence

My findings support in general the hypothesis of conditional convergence, although there is not sign of any strong convergence. There is no single factor alone which, when controlled for, leads to convergence in the results. When I include investments, including FDI, population growth or migration, in combination with resources and/or trade, the convergence result become significant. (See Table 5.5.2 and Table 5.5.3.)

Only the regressions most important for explaining the fit of the theory and/or the pattern in data are included. Some other regressions are presented in appendix A.5.5. I have divided the regressions into two categories, according to which theory they are basically explaining. In Table 5.5.2 I have reported the regressions including the factors important in neoclassical convergence, while Table 5.5.2 includes variables important for the technological catch-up argument. Both tables include a variable controlling for regional resource production.

When only the classical factors from Solow model and investment in human capital are included, the sign on b is negative, but insignificant. Investments prove to be an important determinant for productivity growth. This is an expected result, especially since the Russian economy had been stagnating for many years prior to 1996 and, even though the economy was capital-intensive, the capital equipment used by the firms was not necessarily the most

[13] I have also tested for absolute convergence for the sub-periods, 1996 –1998 and 1999–2004, but the results were not significantly different when the Ingush republic was removed from the sample. The results are attached in appendix (A.5.5).

productive. It is reasonable to expect great potential in Russian firms for productivity growth through investments and adoption of already existing technology.

Human capital seems not to explain the regional differences in productivity. This might be because the model tested is biased from omitting variables, such as migration share, that are expected to be positively correlated with human capital but have negative impact on productivity growth in the Solow model. Including potential omitted variables does not increase the significance on human capital.

Population growth and the migration share have a negative coefficient as predicted by the Solow model. Although the variables have high coefficients, the effects of the variables are uncertain, and their significance depend on that both variables are included. Since population growth includes number of migrants to a region, the variables are highly correlated (ρ=0.9297). When both are included in the analysis, the effect from migration is estimated positive, while population growth is strongly negative. This supports the hypothesis that people migrate for job opportunities and/or that migrants tend to be relatively more resourceful than the average population.

The variable on the share of foreign direct investments in the economy (FDI) is included in the 'Solow-model' table, because it constitutes a part of the total investment share in industry. The variable proves to be significant in most of the specifications. Since the spillover effect from FDI could be rather ambiguous, the positive sign could be applied to the direct investment effect from FDI. On the other hand, FDI differs from investments, in that the FDI variable is correlated with other 'catch-up' variables, such as share of employment in R&D, SME, trade and market potential.

Neoclassical model				
	R5		R6	
Obs	78		78	
R-squared	0.1184		0.2251	
R-squared adj	0.0701		0.1713	
	Coefficient	P>|t|	Coefficient	P>|t|
lncind	-0.0064	0.4920	-0.0265	0.0210
constant	0.0265	0.5840	0.0827	0.0160
control variables				
Investments (sinv)	0.1109	0.0170	0.0601	0.1430
Population growth (n)	-0.9423	0.2250	-0.3957	0.4540
Human capital (prof)	0.0019	0.3020		
FDI/GRP (sfdi)			0.0021	0.0020
Resources (res)			**0.0007**	**0.0450**

Table 5.5. 4. *The Neoclassical Model*

When the FDI-variable is included together with resources, the convergence coefficient becomes significant at the 5% significance level, supporting convergence. Also when we include the combination FDI and 'openness for trade' (trade), the convergence result becomes significant.

Comparing regression R6 (Tab. 4.5.2) and regression R7 (Tab. 5.5.3) we see that including the trade-variable in the regression greatly increases the explanatory power of the model. Together with the regional investments, trade is the most robust variable, explaining a significant share of the variation in regional growth rates. No other factor stands out alone as so important for explaining the variation in the data.

In regression R8 I have included a set of variables, which could be important for catching-up through technological transfer. Trade and FDI are still significant. Migration is the only of the new variables with significant effect, but the coefficient is quite low. Neither spillover, the share employed in R&D (R&D) nor SME has significant effect. R&D is highly correlated with migration, but removing migration does not increase the significance of the R&D variable. The variable intended to capture inter-regional technological spillovers is not significant. When we replace spillover with the variable on market potential in the regression, SME becomes significant (R9), but the coefficient on SME is also quite low. Neither SME nor migration can be considered as very robust, since their significance is sensitive for the combination of variables included in the regression.

The low significance of the R&D variable is not surprising, given that the Russian R&D sector is considered to be highly unproductive and that few innovations have commercial potential (Gianella and Tompson 2007).The low effect of the spillover variable is also not surprising, in view of the scattered production structure in Russia.

The technology gap model						
	R7		R8		R9	
Obs	78		78		78	
R-squared	0.3335		0.4231		0.3345	
R-squared adj	0.2772		0.3467		0.2680	
	Coefficient	**P>|t|**	**Coefficient**	**P>|t|**	**Coefficient**	**P>|t|**
lncind	-0.0298	0.015	-0.0249	0.049	-0.0249	0.0660
constant	0.0829	0.0000	0.091	0.013	0.1090	0.0030
control variables						
investment	0.0776	0.039	0.0868	0.0030	0.0822	0.0530
population growth	-0.9031	0.1370				
FDI	0.0015	0.0180	0.0016	0.0210	0.0017	0.0060
trade	0.0829	0.0000	0.0729	0.0000	0.0858	0.0000
Net migration			-0.0009	0.0010	-0.0007	0.0000
SME			0.0002	0.1640	0.0004	0.0000
R&D			0.2990	0.1220		
spillover			0.0010	0.1340		
market potential					0.0000	0.0380
resourses	0.0015	0.018	0.0004	0.2800	0.0002	0.5950

Table 5.5. 5*. The technology gap model.*

The analysis does not support Krugman's hypothesis of divergence and economic agglomeration. The convergence coefficient has in general a negative sign, although it is not significant in all regressions. The variable reflecting market potential proves to be significant in some occasions, but is not robust. Migration, which should in the presence of economies of scale have a positive impact on growth rates, generally has a negative sign in the results. However, there are, as mentioned, two different underlying motives for migration: climate and better economic opportunities. There is a possibility that migration flows could act differently, according to whether the migrants seek economic opportunities or better climate conditions. Migration to the economic centre with job opportunities could have a positive impact, but is counteracted by the negative impact from 'better climate' migrants. Either way, the hypothesis of higher growth in regions with large market potential has not been supported.

I also tested whether industrial structure could explain some of the differences in growth rates over the period, but no single sector had any explanatory power, and the coefficient were all insignificant. The results from this regression are found in Appendix A.5.5. My findings contrast with Ahrend's results from analysing the importance of industrial structure on regional growth in GRP. Using the almost the same sectoral division as I do,[14] reported by Goskomstat, he found initial industrial structure to be important for economic growth (Ahrend 2002). The reason could be that his analysis concerns a somewhat earlier period, 1990 to 1998, while I am analysing a somewhat later period, where part of the industrial restructuring from the transition had already been accomplished.

The only structural variable that appears to have some explanatory power is the variable reflecting the regional share of resource industry in production. Each of the defined resource sectors (fuel, metals and timber, woodworking and pulp-and-paper industry) shows no significant effect on average growth separately. This indicates that they have some common characteristics important for explaining regional growth performance. All three sectors are important generating large gains for the regions endowed with the resources. The results do not support the 'resource curse' argument, but the hypothesis can neither be rejected The resource variable has a positive coefficient, but is not robust and depend on the variables included in the analysis.

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[14]We both use the sector divisions supplied by Goskomstat; the only difference is that I have merged a few of the sectors, but this should not have any decisive effect.

The result do not change substantially, when calculating the average growth rate following Barro and Sala-i-Martin (1991,1992). My conclusions remain. This implies that the main conclusions of the analysis are not very sensitive for how the average growth rates are calculated.

My results seem to support the hypothesis of conditional convergence predicted by the Solow-model and technology-gap model by Barro and Sala-i-Martin (1997). In addition to initial productivity, of the control variables, investment and trade seem to be most important in explaining the observed differences in regional productivity growth rates. I will in the next run a fixed effect panel regression and compare with my former results.

Comparing the cross-regional analysis with the panel regression

The panel regression supports the result of conditional convergence. Castelli et al. among others have showed that using a panel analysis instead of a cross-regional increases the estimate of the convergence coefficient. An omitted variable bias tends to underestimate the estimate on the convergence coefficient, but the fact that the analysis are more sensitive to business cycles could also cause an upward bias on the estimates. Since the time period is short, I will not focus on the magnitude of the coefficient, but rather use this regression as a check. The results from the panel regression support my general findings in the conditional convergence analysis. The result from the panel regression is shown in table 5.5.4.

Panel regression		
Obs	Regions	Year
	78	8
R-squared	0.8173	
	Coefficient	P>|t|
lncind96	-0.3697	0.0000
constant	0.0593	0.0000

Table 5.5. 4. *Panel Regression*

5.6 Testing for σ-convergence

To know I have focused on what is referred to as β-convergence, or convergence towards mean. In general there is evidence that initially less productive regions have experienced greater growth from 1996 to 2004, conditional on factors like share of investments in production (national and foreign), openness for trade and large resource industry. At the same time, some regions have fallen behind, while other regions have had substantial growth. Even though there is some evidence to indicate that the “laggards” are catching up, it may be that the dispersion in productivity is increasing over time.

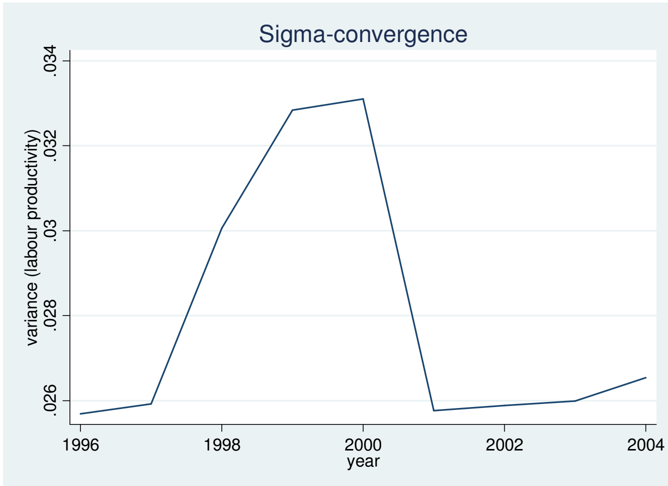

Table 5.5 5: *Sigma-convergence Source: Goskomstat*

From the graph we see that the dispersion in labour productivity is largely varying over time. The variance on log (labour productivity) does a large jump around 1997, possibly related to financial crisis. The large differences remain in the years after, until dropping around 2001. One explanation could be that the industry in the years after the financial crisis was characterized by restructuring. There could be, especially for the years around 1998 that some regions owing industries, which managed to utilize the opportunities after the finical crises, experienced large improvement in labour productivity and thereby improved their relative ranking in productivity. I can not rule out the risk that the conditional convergence pattern is influenced by a shift in relative productivity ranking. At the other hand will I contend that my conclusions from analysing β-convergence remain.

6. Conclusion

I have analysed the regional development of labour productivity levels in the Russian industry, defined as oil and gas extraction, electricity production, mining and quarrying, and manufacturing, in the years when the economy can be considered stabilized under the new market conditions.

My results do not support the hypothesis of absolute convergence, but the conditional convergence predicted by both the Solow-model and the technology-gap model by Barro and Sala-i-Martin (1997) get supported. Investment and trade, but also to large extent FDI stand out as the most important control variables explaining differences in productivity growth. Assuming that trade and FDI are important channels for international technological spillovers, these findings could be explained, among others, by the technology-gap model.

I do not find any tendency for agglomeration among the Russian regions, or any spatial association regarding productivity levels. The regions proving highest productivity growth during the period seem to be scattered around the country.

Differentiated industrial structure across regions has been emphasized as important when analysing regional convergence and is described as a potential barrier for technological transfer. In contrast to Ahrend (2002), who analyse the effect of the industrial structure over a some what earlier period, industrial structure does not explain the observed regional differences in productivity growth rates in my analysis. By the financial crisis most of the inter-sectoral restructuring was accomplished, but there has proven to be substantial intra-sectoral restructuring in the years after.

Only the variable indicating the share of resource industry in the total industrial production prove to have some explanatory power. Although, owing large resource endowment seems not to be neither boosting nor hampering growth in the Russian regions. The middle range results for resource rich regions regarding average productivity growth could have been influenced by the substantial underreporting in that sector.

By analysing for σ-convergence I find that the dispersion in productivity level increased sharply right before the financial crisis in 1998 and remained high in the years after until dropping around 2001. Even though my results seem not to be sensitive for including these years in my average growth estimates, I can not rule out that there has been a shift in the underlying forces working in the economy. For further research should look into these issues in a longer time perspective, especially comparing the period before and after the 1998 financial crisis and the subsequent economic instability.

Bibliography

Abramovitz, M. (1986): ‘Catching up, forging ahead and falling behind’, Journal of Economic History, vol. 66, pp. 385-406.

Aghion P. and P. Howitt (1992): ‘A Model of Growth through Creative Destruction’, Econometrica, vol. 60, pp. 323-351.

Ahrend, R. (2006): ‘Russia’s post-crisis growth: Its sources and prospects for continuation’, *Europe-Asia Studies* 58 (1): 1–24.

Ahrend, R. (2004a): ‘Russian industrial restructuring: Trends in productivity, competitiveness and comparative advantage’. OECD, Economics Department Working Paper no. 408.

Ahrend R. (2004b): ‘Accounting for Russia`s Post_Crisis Growth’. OECD, Economics Department Working Papers no. 404.

Ahrend R. and W. Tompson (2005): ‘Fifteen Years of Economic Reform in Russia: What Has Been Achieved? What Remains to Be Done?’ OECD, Economics Department Working Paper no. 430.

Arrow K. (1962): ‘The economic implications of learning by doing’, Review of Economic Studies, vol. 29, pp. 155-173.

Barro, R. J. and X. Sala-i-Martin (1991): ‘Convergence Across States and Regions’, Brookings Papers on Economic Activity, vol. 1991, No. 1, pp.107-182.

Barro, R. J. and X. Sala-i-Martin (1992): ‘Convergence’, The Journal of Political Economy, Vol. 100, No. 2, pp. 223-251.

Ahrend, R. (2002): ‘Speed of reforms, initial conditions, Political Orientation, or What? Explaining Russian Regions’ Economic Performance’, Working Paper no.10, DELTA, Paris.

Barro, R. J. and X. Sala-i-Martin (1997): ‘Technological Diffusion, convergence, and growth’, Journal of Economic Growth, vol.2, pp. 1-27.

Barro, R. J. and X. Sala-i-Martin (2004): *Economic growth*, 2nd edn. The MIT Press Cambridge, Massachusetts London.

Berkowitz, D. and D. N. DeJong (2001): 'Policy reform and growth in post-soviet Russia', European Economic Review, vol. 47, pp. 337-352.

Blakkisrud, H. (2006): 'What's to be done with the North' in H. Blakkisrud, and G. Hønneland, eds: *Tackling Space: Russian Politics and the Russian North.* University Press of America, Lanham, MD.

Bradshaw M. (2006): 'Observation on the geographical Dimension of Russia's resource abundance', Eurasian Geography and Economics, Vol. 47, no. 6, pp. 724-746.

Brezis, E. S., P. R. Krugman and D. Tsiddon (1993): 'Leapfrogging in International Competition: A Theory of Cycles in National Technological Leadership', The American Economic Review, Vol. 83, No. 5, pp. 1211-1219.

Cass, D. (1965): 'Optimum Growth in an Aggregative Model of Capital Accumulation', Review of Economic Studies 32, pp. 233-40.

Caselli F., G. Esquivel and F. Lefort (1996): 'Reopening the Convergence Debate: A new Look at Cross-Country Growth Empirics ', Journal of Economic Growth.

CEFIR (2003):'Monitoring the Administrative Barriers to Small Business Development in Russia', 3rd round, Moscow.

Dixit, A. and J. Stiglitz (1977): 'Monopolistic competition and optimum product diversity', American Economic Review, vol. 67, pp. 297-308.

Dolinskaya, Irina (2002), 'Transition and Regional Inequality in Russia: Reorganization or Procrastination?', IMF Working Paper 02/169.

ECE (United Nations: Economic Commission for Europe) (2004): *Economic Survey of Europe*. No.1. New York.

Fagerber, J. (1995): 'Convergence or divergence? The impact of technology on why growth rates differ', J Evol Econ, no. 5, pp. 269-284.

Gerschenkron, A. (1962): *Economic Backwardness in Historical Perspective,* Harvard University Press.

Gianella C. and W. Tompson (2007): 'Simulating Innovation in Russia: The Role of Institutions and Policies'. OECD, Economics Department Working Paper.

Granberg, A.G. (2000): 'Regional development and regional policy in new Russia', in H. Westlund, A. Granberg and F. Snickars, eds: *Regional Development in Russia: Past Policies and Future Prospects.* Edward Elgar, Northampton, MA.

Gregory, P.R. and R. C. Stuart (1986): *Soviet Economic Structure and Performance*, 3rd edn. Harper & Row, New York.

Gluschenko, K. (2005): 'Inter-regional price convergence and market integration in Russia', Institute of Economics and Industrial Engineering, Siberian Branch of Russian Academy of Sciences, Novosibirsk.

Islam N.(1995): 'Growth Empirics: A Panel Data Approach', Quarterly Journal of Economics, vol. 110. pp.1127-70

Koopmans, T. C. (1965): 'On the Concept of Optimal Economic *Growth',* In the Econometric Approach to Development Planning. Amsterdam: North- Holland.

Koxzlov K. and K. Yudaeva (2004): 'Imitations and Innovations in a Transition Economy', CEFIR, Moskow.

Krugman, P. (1991): *Geography and Trade,* Leuven University Press, Leuven and The MIT Press Cambridge, Massachusetts London.

Krugman, P. (1987): 'The Narrow Moving Band, the Dutch Disease and the Competitive Consequences of Mrs. Thatcher. Notes on Trade in the Presence of Dynamic Scale Economies.' *Journal of Development Economics.* 27: 41-55.

Krugman, P. and Venables, A. (1990). 'Integration and the competitiveness of peripheral industry' in C. Bliss and J. Braga de Macedo, eds., *unity with Diversity in the European Community,* Cambridge: Cambridge University Press.

Mankiw, G. N., D. Romer and D. N. Weil (1992): ‘A Contribution to the Empirics of Economic Growth’, The Quarterly Journal of Economics, Vol. 107, No. 2, (May, 1992), pp. 407-437 Published by: The MIT Press.

Maurseth P. B. (2003): ‘Divergence and dispersion in Russian economy.’ *Europe-Asia Studies*, vol. 55, nr. 8 . Routledge.s. 1165-1185.

Maurseth P. B. (2006): ‘Economic Geography: Dispersion and Centralization’ in H. Blakkisrud, and G. Hønneland, eds: *Tackling Space: Russian Politics and the Russian North.* University Press of America, Lanham, MD.

Mehlum, H. Moene, K and Torvik, R. (2006):’Institutions and the Resource Curse.’ *The Economic Journal,* 116 (January), 1-20.

Nielsen Ö. V. (2006): ‘Regionale forskjeller i Russland’, Master Thesis at the University of Oslo, Economic Department.

OECD Economic Surveys (1995): *The Russian Federation.* Paris: OECD.

Popov, V. (2001): ‘Reform strategies and economic performance of Russia’s regions’, World Development, vol. 29, no. 5, pp. 865-886.

Romer, P. M. (1987): ‘Growth based on Increasing Returns Due to Specialization’, American Economic Review, vol. 77, pp. 56-62.

Romer, P. M. (1990): ‘Endogenous Technological Change’, Journal of Political Economy, 98, pp. 71–102.

Ross, C. (2002): *Federalism and democratisation in Russia.* Manchester University Press, Manchester.

Rudiger, A. and W. Tompson (2005): ‘Fifteen years of economic reform in Russia: What has been achieved? What remains to be done?’ World Bank, Economic Department Working Paper no.430.’

Sachs, J. D. and Warner, A.M. (1997): *Natural Resource Abundance and Economic Growth.’* Center for International Development and Harvard Institute for International Development. Harvard University: Cambridge MA.

Sakwa R. (2000): 'Putin's New Federalism', EWI Russian Regional Report 5 (21).

Sakwa, R. (2002): *Russian Politics and Society*, 3rd edn. Routledge, London.

Solow R. M. (1956): 'A contribution to the theory of economic growth', Quarterly Journal of Economics, vol.70, pp. 65-94.

Stock J. H. and M. W. Watson (2003): *Introduction to Econometrics.* Pearson Education, Inc. Boston.

Sutela, P. (2003): 'The Russian market economy', Aleksanteri Institute, Helsinki.

World Bank (2004): 'From Transition to Development, A Country Economic Memorandum for the Russian Federation'.

A.4

Labour productivity: Top5			
Regions	**Productivity 1996**	**Regions**	**Productivity 2004**
Tyumen	216.080	Tyumen	337.339
Sakha (Yakutia) republic	125.463	Sakha (Yakutia) republic	153.299
Chukotka auton. okrug (10)	70.029	Komi republic (13)	113.205
Krasnoyarsk	60.391	Lipetsk oblast (14)	112.04
Vologda oblast (12)	55.122	Krasnoyarsk	111.536

Table A 4.1. Labour productivity: Top5

Labour productivity: Bottom 5			
Regions	**Productivity 1996**	**Regions**	**Productivity 2004**
Ingush republic	3.838	North Ossetia - Alania	11.417
Dagestan republic	8.639	Altai republic	12.626
North Ossetia - Alania	9.770	Ingush republic	14.917
Adygeya republic	11.386	Dagestan republic	15.364
Altai republic	11.910	Adygeya republic	17.758

Table A 4.2 Labour productivity: Bottom 5

Variable	Mean	Std. Dev.	mean adjusted Std. Dev.[15]	Min	Max	Difference	Median	Lower quartile	Upper quartile
cind1996	31.838	26.758	34,419	8.639	216.080	207.441	19.249	25.601	38.143
cind1997	33.568	27.067	33,022	9.749	225.544	215.795	19.241	28.094	40.962
cind1998	33.255	30.995	38,170	9.219	258.688	249.469	18.609	25.959	38.393
cind1999	35.189	33.459	38,940	7.015	274.901	267.886	20.098	28.747	40.983
cind2000	44.940	43.658	39,785	7.759	354.716	346.957	24.092	36.506	49.855
cind2001	46.652	38.145	33,486	11.039	284.316	273.277	25.063	39.231	53.706
cind2002	44.540	34.814	32,011	11.323	275.350	264.027	24.257	39.052	51.270
cind2003	47.792	42.727	36,613	11.668	361.165	349.496	25.043	41.035	54.081
cind2004	50.807	43.115	34,753	11.417	337.339	325.922	26.006	40.503	56.960

Table A 4.3. Annual average labour productivity

[15] Weighted by productivity average over the period as a fraction of the annual average.

Regional average productivity growth	Mean	Std. Dev.	Min	Max	Differanse	Median	Lower quartile	Upper quartile
Average 1996-2004	0.0747	0.05	-0.028	0.231	0.259	0.065	0.044	0.105
ag_ing[16]	0.083	0.091	-0.028	0.752	0.78	0.065	0.044	0.106
g1997	0.068	0.171	-0.577	0.482	1.059	0.048	-0.019	0.168
g1998	0.017	0.377	-0.561	2.819	3.380	-0.060	-0.124	0.076
g1999	0.059	0.225	-0.601	0.841	1.442	0.047	-0.082	0.170
g2000	0.288	0.305	-0.094	2.015	2.109	0.224	0.093	0.369
g2001	0.097	0.205	-0.344	1.089	1.433	0.084	-0.032	0.208
g2002	-0.028	0.174	-0.580	0.494	1.074	-0.036	-0.099	0.086
g2003	0.089	0.252	-0.173	2.009	2.181	0.055	-0.022	0.139
g2004	0.062	0.170	-0.365	0.536	0.901	0.031	-0.058	0.175

Table A. 4.4. Annual average growth

[16] ag_ing is the estimate on average productivity including Ingush republic.

Top10		Bottom10	
Region	**Avg. growth**	**Region**	**Avg. growth**
Ingush republic	0.1508	Omsk oblast	-0.0891
Sakhalin oblast	0.1288	Evrei autonomous oblast	-0.0357
Arkhangelsk incl. Nenets	0.1223	Ulyanovsk oblast	-0.0153
Astrakhan oblast	0.1210	Orenburg oblast	-0.0082
Saint-Petersburg	0.1166	Kamchatka incl. Koryak	0.0017
Moscow oblast	0.1130	Volgograd oblast	0.0048
Lipetsk oblast	0.1115	Altai republic	0.0065
Komi republic	0.1108	Bashkortostan republic	0.0100
Magadan oblast	0.1060	Altai krai	0.0105
Kursk oblast	0.0797	Tuva republic	0.0109

Table A. 4.5. Top and Bottom 10

A.5:

6.1 The concepts of convergence

Driving expressions for β -convergence from the Solow-model

In chapter 3 I showed that the growth rate in the Solow model could be expressed approximately as a function of the distance to steady-state (eq. 3.7). By solving this dynamic equation, eq. 3.7, we get an expression for the growth in output per unit of effective labour ($\ln\left(\frac{\hat{y}(t)}{\hat{y}(t_0)}\right)$) as a function of initial output per effective unit of labour ($\hat{y}(t_0)$), eq. A.5.1. t_0 is defined as the initial starting point. Dividing the growth in output per unit of effective labour into the rate of technological growth (x) and growth in output per capita ($\ln\left(\frac{y(t)}{y(o)}\right)$), we get eq. A.5.2. Let the length of the time interval (t_0 ,t) be T and $t_0 = 0$. By dividing (eq. A.5.2.) through with T we get (eq.A.5.3), an expression of average growth rate over a period of T years as a function of the regional steady-state and initial income.

A.5.1 $$\ln\left(\frac{\hat{y}(t)}{\hat{y}(t_0)}\right) = \left(1 - e^{-\beta t}\right)\ln\left(\frac{\hat{y}^*}{\hat{y}(t_0)}\right)$$

A.5.2 $$\ln\left(\frac{y(t)}{y(o)}\right) = x + \left(1 - e^{-\beta t}\right)\ln\left(\frac{\hat{y}^*}{\hat{y}(o)}\right), \quad \ln\left(\frac{\hat{y}(t)}{\hat{y}(o)}\right) = \ln\left(\frac{y(t)}{y(o)}\right) - x$$

A.5.3 $$\frac{1}{T}\ln\left(\frac{y(T)}{y(o)}\right) = x + b\ln\left(\frac{\hat{y}^*}{\hat{y}(o)}\right) \qquad b = -\frac{\left(1 - e^{-\beta T}\right)}{T}$$

Barro and Sala-i-Martin (1991, 1992) use a discrete version similar to A.4.3 as a starting point for their convergence analyses, were the average growth rates (ag) are calculated according to equation A.5 .4.

A .5.4 $$ag = \frac{1}{T}\ln\left(\frac{y_T}{y_0}\right)$$

Driving expressions for σ –convergence

By taking a discrete version of A.5.3) and include a random disturbance term ($u_{i,t}$), an expression for the variance in productivity can be derived. Assuming that the ($u_{i,t}$) is independently distributed, has a zero mean and constant variance, σ_u^2, then the variance of $\ln y(t)$, σ_t^2 , can be expressed by the following dynamics, (eq. A.5.5):

A.5.5) $$\sigma_t^2 = e^{-2\beta}\sigma_{t-1}^2 + \sigma_u^2$$

From this expression we see that β-convergence is a necessary, but not sufficient condition for σ-convergence.

6.2 Cross-regional analysis

Table of control variables

Code	Variable name	Description	Comment	Year
ag	Average growth	$ag_i = \frac{1}{8}\sum_{t=1997}^{2004} g_{i,t}$	$g_{i,t}$ is the regional yearly growth rates	1997-2004
lncind	Labour productivity	Log (value added/employees)		1996
sinv	Investments	investment/value added		1996
n	Population growth			1997
prof	Human capital	Bachelor or higher		2000
sfdi	FDI	$sfdi_i = fdi_i / GRP_i$	US$	1996
strade	Trade	$strade_i = (import_i + export_i)_i / GRP_i$	US$	1997
totmig	Migration	net number of migrants	1000	
smig	Migration share			
wsme	SME	$wsme_i = \frac{\bar{y}}{y_i} \cdot sme_i$	$\bar{y}$: regional average GRP	1996
mp	Market potential	$mp_{1996,i} = \sum_{j \neq i} \frac{GRP_{1996,j}}{d_{1996,j}} + GRP_{1996,i}$ [17]		1996
res	Resources	resources=fuel + metals [18] + timber, woodworking and pulp-and-paper industry	% share of value added	1997
srd	R&D	number employed in R&D/total number of employees		1996
spillover	Spillover	$spillover_{1996,i} = \sum_{j \neq i} \frac{cind_{1996,j}}{d_{1996,j}}$	$cind_j$ is productivity in region j	1996

Table A.5.1: *Variables used in the analysis. Source: Goskomstat*

[17] For a closer description see below.

[18] Metals incl. ferrous and non-ferrous metal production.

Industry sectors

I use the classification given by Goskomstat. The sectors marked with *are merged from the original classification. The variables are measures as share of value added in the industry sector in total.

Code	Industry sectors	year
el	Electricity production	1997
fuel	Fuel industry	1997
metal	Metal extraction and production: ferrous + non-ferrous metals*	1997
petchem	Chemical and petrochemical industry	1997
machmet	Machine-building and metal cutting industry	1997
timbcell	Timber, woodworking and pulp-and-paper industry	1997
light	Light industry	1997
constcer	Constructions materials + ceramic and porcelain production*	1997
foodgrain	Food processing + grain and animal food industry*	1997

Table A.5.2: *Industry sectors used in the analysis. Source: Goskomstat*

Market potential

I will use a weighted sum of all Russian regions` GRP, including region i`s GRP, as an indicator on region i`s "market potential" (mp). The weight are based on the other regions distance to region i, such that GRP in regions far away will have little influence. The formula for mp_i can be expressed as follows:

A.5.6. $$mp_{1996,i} = \sum_{j \neq i} \frac{GRP_{1996,j}}{d_{1996,j}} + GRP_{1996,i} \quad \forall i$$

The distance is calculated utilizing the regions latitude and longitude degrees (latd and latm) and minutes (latm and lonm). These can be converted into decimal degrees (lat and lon) by the following formulas:

$$lat = latd + \frac{latm}{60}$$
$$lon = lond + \frac{lonm}{60}$$

"lat" and "lon" are further converted into radians:

$$\left.\begin{aligned} X_i &= (90 - lat) \times \frac{\pi}{180} \\ Y_i &= lon \times \frac{\pi}{180} \end{aligned}\right. \quad \forall i$$

The variables X_i and Y_i are used as inputs in an arc distance computation, which generates the distance between the regional centres:

$$dist = 3959.0 \times \arccos\{\cos|Y_i - Y_j| \times \sin X_i \times \sin X_j + \cos X_i \times \cos X_j\} \quad i \neq j$$

6.3 Missing values

The price index for Chukotka

The 1997 observation on the industrial price index for Chukotka autonomous okrug ($P_{ind,chukotka}$) is missing.. Since I will keep Chukotka autonomous okrug in my sample I will extrapolate a value for $P_{Ind,chukotka}$ in 1997 ($P_{Ind,chukotka,1997}$). There are several ways to do this. Because of the large fluctuations in prices over time, observations on price indexes for later years do not necessarily reflect the price level in 1997. The industrial price index for

Chukotka seem to follow the consume price index for Chucokta ($CPI_{chukotka}$). By regression I found that the first lag of $CPI_{chukotka}$ best explains the variation in $P_{ind,chukotka}$ over the period 1998-2004. Based on the coefficient from this regression (tab. A.5.3.) and the observations on $CPI_{chucotka}$ in 1996 I can calculate $P_{Ind,chukotka,1997}$.

1.lag Consum Price Chukotka				
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	67,0101416	17,09074599	3,920844	0,011173
123,6	0,40066902	0,12984738	3,085692	0,027293

Table A.5.3.: Estimates $P_{Ind,chukotka,1997,}$. source: Goskomstat

Using the numbers from the regression in tab.A.4.3.1 the calculation of $P_{Ind,chukotka,1997}$ can be expressed by equation A.5.7.:

A.5.7. $$P^{1997}_{ind,chukotka} = 67{,}01 + 0{,}401 * P^{1996}_{cons,chukotka}$$

Employment data

Total employment in the industrial sector is calculated from the reported share of employment in the industry (oil and gas extraction, electricity production, mining and quarrying, and manufacturing industry) times the total regional employment. Observations for the industrial employment share are missing for 1996. They are not included in the statistics I have become from Goskomstat. The time series includes the years 1995 to 2004 except 1996. To construct a measure of industrial productivity I need a full time series of the employment in the industry. Since I have observations on the employment share in 1995 and 1997 I can replace the missing observation on 1996 by the average of 1995 and 1997 employment share. For Chukotka is also the observation on total employment in 1996 missing. I replace the missing 1996 observation with data on total employment in Chukotka in 1997, adjusted for the regional average fall in employment from 1996 to 1997[19].

[19] The average regional employment is approximately 20% higher in 1996 than in 1997.

Data on industrial structure

Several observations are missing on the share of different industry sectors in. How many observations, which are missing varies from sector to sector. The electric power industry, machine-building and metal cutting industry, timber, woodworking and the pulp-and-paper industry, building materials industry, the light industry and the food industry have none or almost non missing values, while the ceramic and porcelain industry has almost half of its values missing.

The main reason that observations are missing for a sector is either that the sector do not exist in that region or that the sector only constitute a marginal share of the region's industrial production. The ceramic and porcelain sector are very small in Russia and of insignificant size on national basis. Also the resource sectors, especially the fuel and metallurgy industry, have some missing values. This is not surprising since production in these sectors is mainly concentrated in a few regions with large natural resource endowments. Since I am interested in the effect of regional specialization, missing values for sectors, which in general only constitute a small share of the total regional production, are not critical, even though the amount of missing values is significant for certain sectors. For example the resource curse argument is concerned about regions having large resource endowments. Observations for all these regions are present. To control for initial industrial structure I use observations for 1997 when analysing growth in the second period. Since the industrial structure does not change significantly from 1997 to 1998 I have replaced the missing values for 1997 observations from 1998, when they exist and zero for the rest.

6.4 Correlation table

	ag	lncind	sinv	n	education	smig	migration	sfdi	strade	wsme	mp	spillover	srd	res
ag	1													
lncind	-0.0371	1												
sinv	0.2604	0.006	1											
n	-0.0861	-0.2559	0.2496	1										
prof	0.1269	-0.1936	0.1742	0.3816	1									
smig	-0.0706	-0.3311	0.0312	0.9296	0.3081	1								
totmig	-0.1001	-0.0133	0.0308	0.4544	0.5568	0.4414	1							
sfdi	0.3367	0.0732	0.1417	-0.1095	0.2274	-0.1384	0.2697	1						
strade	0.3663	0.2457	0.0845	0.1868	0.2837	0.1305	0.275	0.1907	1					
wsme	0.2417	-0.1184	-0.0617	0.0782	0.5092	0.1072	0.1243	0.0828	0.1604	1				
mp	0.066	0.3058	0.0453	0.3023	0.402	0.2779	0.7202	0.4093	0.3032	0.1296	1			
spillover	0.2081	-0.077	-0.1099	0.1984	0.4266	0.2652	0.5119	0.4461	0.2313	0.386	0.7665	1		
srd	0.0346	0.0774	-0.1417	0.2881	0.6546	0.2921	0.8197	0.3232	0.3001	0.3865	0.6754	0.5447	1	
res	0.1618	0.6535	0.2594	-0.2072	-0.3072	-0.3121	-0.2208	-0.0534	0.2811	-0.1957	0.0713	-0.169	-0.2403	1

***A.5.4.**: Correlation table. Source Goskomstat.*

6.5 Empirical results

Testing for absolute convergence

Including dummies for outliers

Absolute convergence		
Obs	79	
R-squared	0.6433	
	Coefficient	P>|t|
Incind	0.0000	1.0000
constant	0.0747	0.0560
d_Ingush	0.5731	0.0000
d_Sakha	-0.0410	0.0710
d_Tyumen	-0.0048	0.8680

Table 5.5. *Absolute Convergence. Source: Goskomstat*

Testing for convergence among the 1/3 least productive

	Absolute convergence bottom 1/3			
	with Ingush		Ingush dropped	
Obs	79		78	
R-squared	0.4911		0.0033	
	Coefficient	P>|t|	Coefficient	P>|t|
Incind96	-0.22882	0.0440	0.0098	0.6990
constant	0.716862	0.0260	0.0496	0.4540

Table 5.6. Absolute Convergence bottom 1/3. Source Goskomstat

Testing for absolute convergence in the two periods up to 1998 and after

Absolute convergence 1996-1998				
	with Ingush		**Ingush dropped**	
Obs	79		78	
R-squared	0.0996		0	
	Coefficient	P>|t|	Coefficient	P>|t|
lncind96	-0.1024	0.27	0.0001	0.994
constant	0.3773	0.235	0.0251	0.703
Absolute convergence 1999-2004				
R-squared	0.0104		0.0003	
	Coefficient	P>|t|	Coefficient	P>|t|
lncind96	-0.0118	0.4580	0.0017	0.8670
constant	0.1336	0.0190	0.0847	0.0130

Table A..5 7. Absolute Convergence in 1996 – 2004. Source Goskomstat

- **Robustness test of my results**

Regression: data deflated by CPI				
	with Ingush		Ingush removed	
Obs	79		78	
R-squared	0.0100		0.0407	
	Coefficient	P>|t|	Coefficient	P>|t|
lncind	-0.0130	0.6900	0.0220	0.0750
constant	0.1181	0.2850	-0.0018	0.9630

Table A. 5 8. *CPI Regression. Source Goskomstat*

6.6 Testing for conditional convergence

Testing the importance of differentiated industrial structure

Industrial structure		
Obs: 78	A3	
R-squared	0.1857	
R-squared adj	0.0500	
	Coefficient	P>|t|
Lncind	-0.0139	0.3700
Constant	-0.0517	0.8790
control variables		
sinv96	0.1123	0.0780
El	0.0015	0.6530
Fuel	0.0016	0.6330
Petchem	0.0014	0.6640
Machmet	0.0015	0.6370
Timbcell	0.0035	0.3270
Light	0.0016	0.6450
Metal	0.0017	0.5990
Constcer	-0.0004	0.9090
Foodgrain	0.0015	0.6730

Table A.5.9. *Industrial Structure. Source Goskomstat*

Additional regressions on conditional convergence

Conditional convergence				
Obs: 78	A1		A2	
R-squared	0.2182		0.3696	
R-squared adj	0.1639		0.3066	
	Coefficient	P>|t|		
Lncind	-0.0163	0.2330	-0.0273	0.0240
Constant	-0.0107	0.8120	0.1127	0.0020
control variables				
investment share	0.1414	0.0120	0.0610	0.0310
population growth	-4.2616	0.0050		
education (prof)	0.0032	0.0850		
migration share	3.0674	0.0160		
FDI			0.0018	0.0020
Trade			0.0869	0.0000
Migration			-0.0007	0.0000
SME				
share employed in R&D				
market potential			0.0000	0.0350
Resourses	0.0007	0.0830	0.0003	0.5060

Table A.5 10*. Conditional Convergence. Source Goskomstat*

6.7 Robustness test: Using Barro's and Sala-i-Martin's growth rate

I have here calculated the growth rate following the method used by Barro and Sala-i-Martin (1991,1992).

	BSM1		BSM2		BSM3	
Obs	78		78		78	
R-squared	0.0024		0.1069		0.2941	
R-squared adj			0.0580		0.2007	
	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|
lncind	-0.0038	0.5980	-0.0063	0.4320	-0.0224	0.0480
constant	0.0663	0.0050	0.0272	0.5120	0.0819	0.0120
control variables						
investment share			0.0953	0.0100	0.0710	0.0060
population growth			-0.6685	0.2660		
education (prof)			0.0011	0.4760		
FDI/GRP					0.0013	0.0070
trade/GRP					0.0302	0.0990
Migration					-0.0007	0.0060
SME					0.0002	0.1080
share employed in R&D					0.2011	0.3070
market potential					0.0000	0.0430
resourses					0.0003	0.3800

Table A. 5 11. *Regression using Barro and Sala-i-Martin growth rate. Source Goskomstat*